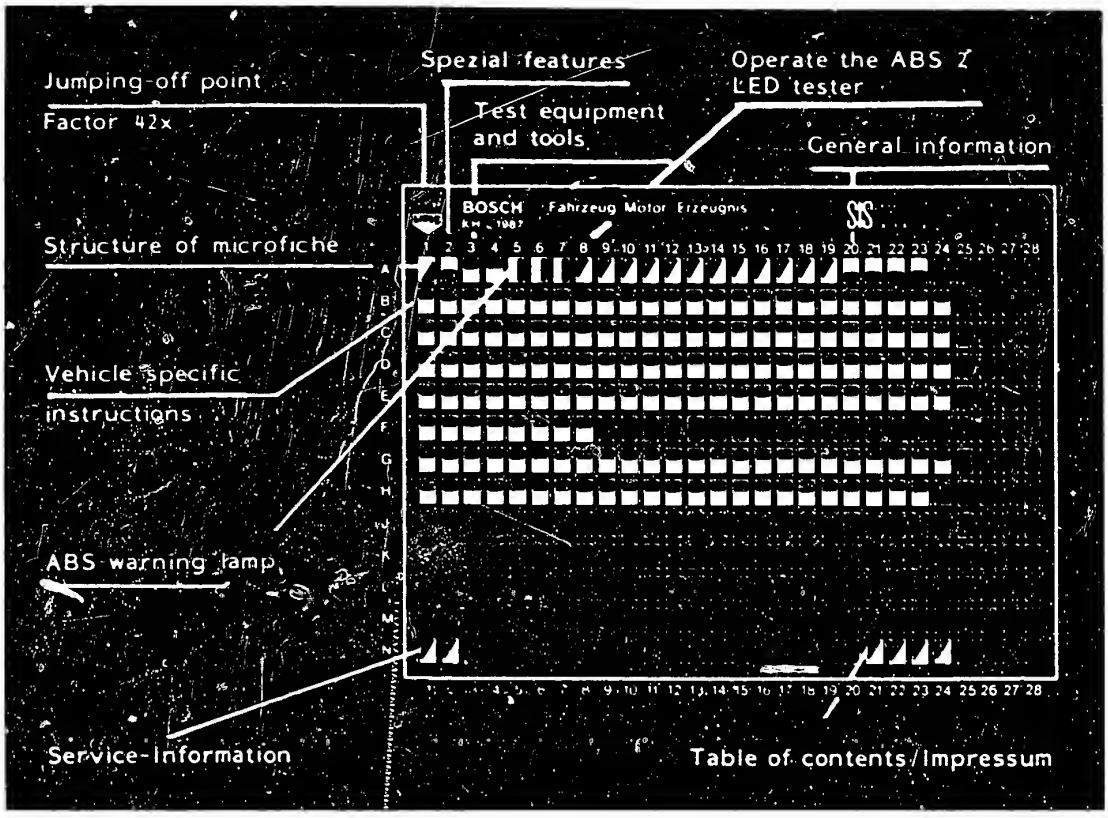
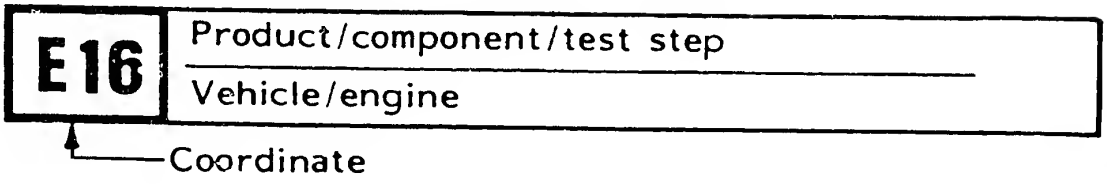
Structure of microfiche

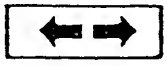


1. Read from left to right
2. Title of microfiche (appears on each coordinate)

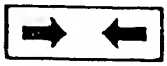


3. Limits of section


Beginning


Mid-section


End


One-page section

4. Purely vehicle-specific passages in the text are marked with a vertical bar.

5. Reference to relevant working steps in the test specifications, e.g. coordinate C6.

SPECIAL FEATURES

The ABS tester ETT 016.00 was replaced at the end of 85 by the ABS 2 LED tester. For testing with the ABS 2 LED tester, all ABS vehicles, previously covered on 13 microcards, have been summarized on this special microcard.
Future ABS microcards will again appear in SIS design, but with ABS 2 LED tester.

Vehicles	Wheel-speed sensors	Channels	For test chart and vehicle-specific information see Coordinate
Audi (with two-wheel drive) 80,90 → 12.87	4	4	B 1
100,200 → 6.87	4	4	B 1
Audi Quattro → 8.86	4	3	D 1
BMW 3 series (with two-wheel drive) → 8.87	4	3	D 1
5 series (E 28) → 12.87	4	4	B 1
6 series	4	4	B 1
7 series → 8.86	4	4	B 1
Lancia Thema	4	4	B 1
Mercedes type 201	3	3	G 1
other models with the exception of W 124	3	3	G 1
Opel Senator/ Monza → 8.87	4	3	D 1
Porsche 928 → 8.87	4	3	D 1
Volvo 740/760 → 8.86	3	3	G 1

TEST EQUIPMENT AND TOOLS

Description	Designation	Part Number
ABS 2 LED tester	KDAS 0003	Ordering address: Robert Bosch GmbH KH/VKD 3 Postfach 41 09 60 7500 Karlsruhe 41
Adapter lead (included with tester)	KDAS 0003/2	
Charging and bleeding device		e.g. ATE Part No. 3.9302-1000.4 1)
Bleeder fitting for connecting the charging and bleeding device to the master-cylinder fluid reservoir		ATE Part No. 3.9302.0702.2 1)
Bleeder hose		ATE Part No. 3.3590.2300.1 1)
Auxiliary hose		ATE Part No. 3.9302.0704.2 1)
Brake-pedal actuating device		ATE Part No. 3.9312.0100.4 1)

1) obtainable from: Alfred Teves GmbH
Guerickestraße 7
6000 Frankfurt (Main)

Description	Designation	Part Number
Pressure tester Tester for low- and high-pressure testing of hydraulic brake systems		e.g. ATE Part No. 3.9305-0200.4 1)
Double box wrench, open 9 x 11 mm		Hazet Part No. 612 2)
Vessel for catching brake fluid approx. 1 l Brake fluid: DOT 4 or brake fluid of vehicle manufacturers		
Digital multimeter e. g. Bosch	MMD 301	0 684 500 301

Aids

Use only genuine brake lines of the vehicle manufacturers.

Description	Part Number
Grease for wheel-speed sensors	Molykote Longterm 2
Protective cap for brake lines	1 900 508 002 (100 pieces)
Protective caps for brake-line connections on hydraulic modulator	1 900 508 004 (100 pieces)

1) obtainable from: Alfred Teves GmbH, Guerickestr. 7
6000 Frankfurt (Main)

2) Firma Hazet, Remscheid

OPERATION OF ABS WARNING LAMP (NEW)

The warning lamp, which is built into the instrument panel, comes on when the ignition is switched on.
After starting and reaching idle speed, the ABS warning lamp goes out (terminal 61 of alternator supplying voltage to ABS controller).
When, for the first time after starting, the vehicle exceeds a speed of approx. 6 km/h with all 4 wheels, the ABS system checks itself automatically (BITE sequence).
This process is repeated whenever the ignition is switched off and the engine is started again.
In addition, the ABS constantly checks itself to a certain extent while driving.

The lighting up of the ABS warning lamp tells the driver that the ABS is not in proper working order.

In this case, the ABS is switched off automatically.
Nevertheless, the vehicle can still be braked with the conventional braking system.
It is, however, possible for the wheels to lock.
This applies both in the case of a malfunction, and also if the ABS has been switched off by the ABS switch (if applicable).

Operation of ABS warning lamp (old)

The warning lamp comes on when the ignition is switched on. When the vehicle reaches a speed of over 6 km/h (with all 4 wheels), the warning lamp goes out.
This process is repeated whenever the ignition is switched off and on.
All other functions are as described above.

ABS switch in Audi vehicles

The switch makes it possible for the driver, as desired, to test the brakes or the road conditions with the aim of intentionally locking the wheels.

If, on exceptionally poor road surfaces, such as gravel or snow-covered ice, on which utmost caution and slow driving are necessary anyway, it is accepted that the wheels may lock when braking, it may be possible, by switching off the ABS, to obtain a shortening of the stopping distance.

After normal road conditions have resumed, the system should be switched on again immediately with the ABS switch.

Caution:

The electrical system is designed such that, when the engine is stopped with the ABS system off, the ABS system is switched on again automatically when the engine is re-started.

Checking the ABS warning lamp

ABS-equipped vehicles are brought into the workshop with one of the following customer complaints:

- Warning lamp does not come on after switching on the ignition.

- Warning lamp does not go out after reaching a vehicle speed of more than 6 km/h (old) or after reaching idle speed (new).

- Warning lamp comes on again while driving or comes on occasionally.

  Occasional lighting up of the warning lamp may be caused by an insufficiently charged battery. The lamp comes on only when there is undervoltage, e.g. after loads have been switched on at idle.

The lighting up of the ABS warning lamp tells the driver that the ABS is not in proper working order.

Check the complaint yourself before testing the entire ABS system with the ABS tester.

For reasons of safety, the ABS may be tested only with the ABS tester.

The ignition must always be switched off when connecting the ABS tester and when disconnecting and connecting the controller.

If you have found a fault with the ABS tester, always disconnect the controller before conducting further trouble-shooting.

HOW TO OPERATE THE ABS 2 LED TESTER

1. General

The BOSCH ABS 2 LED TESTER checks the ABS components in passenger cars with hydraulic brake systems.

The following BOSCH ABS systems can be checked:

- All ABS 2 versions (e. g. ABS 2, ABS 2 B)
- ABS 2 B part of electronic traction control (ASR)

The tester checks the peripheral system components in 6 program steps:

- Hydraulic modulator
- Motor relay
- Valve relay
- Wheel-speed sensors
- Warning lamp
- Acceleration sensor
- Wiring harness
- Plug-in connections
- Ground leads
- Stop-lamp switch signal
- Alternator signal

The ABS controller is not checked.

The self-diagnosis in the ABS controller makes it unnecessary to additionally check the controller with the tester.

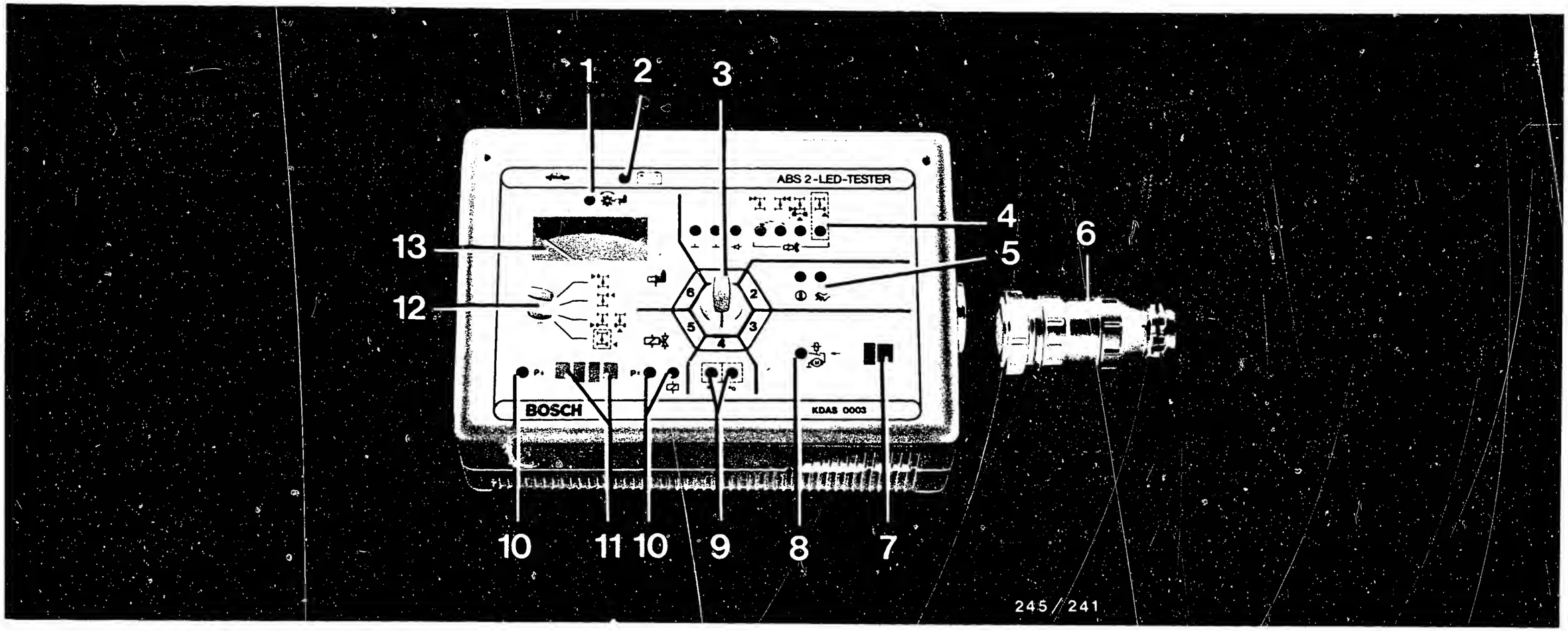
A dynamic brake analyzer is not required for testing the ABS.

If a dynamic brake analyzer is used, there is the danger of the vehicle jumping out of the rollers.

Responsibility for the use of a dynamic brake analyzer lies with the testing staff.

2. Construction of tester

The faults are indicated by LEDs with the exception of the wheel-speed sensor signals, which can be read off on the pointer instrument.

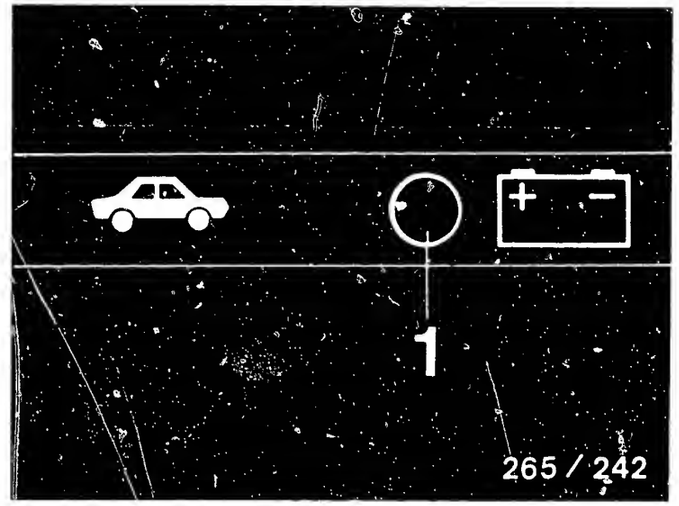


1 = 1 LED for wheel speed in program switch position 6
2 = 1 LED for battery voltage
3 = Program switch
4 = 7 LEDs for program switch position 1
5 = 2 LEDs for program switch position 2
6 = Adapter lead for connection to ABS wiring harness in vehicle
7 = Key for motor-relay energization in program switch position 3
8 = 1 LED for program switch position 3
9 = 2 LEDs for program switch position 4
10 = 3 LEDs for program switch position 5
11 = 2 keys for triggering solenoid-operated valve functions. Pressure holding and pressure reduction in program switch position 5
12 = Rotary switch for selection of individual wheels. Operational in program switch positions 5 and 6
13 = Pointer instrument for program switch position 6

Construction of tester (continued)

Description of symbols

The tester is powered by the vehicle battery. The supply voltage is monitored throughout the entire test procedure in all program switch positions.
An LED constantly indicates whether the voltage is sufficient (top diagram, Item 1).



Program switch position 1 (Bottom diagram)

1 = LED for ground connection 1

2 = LED for ground connection 2

3 = LED for diode for energization of warning lamp

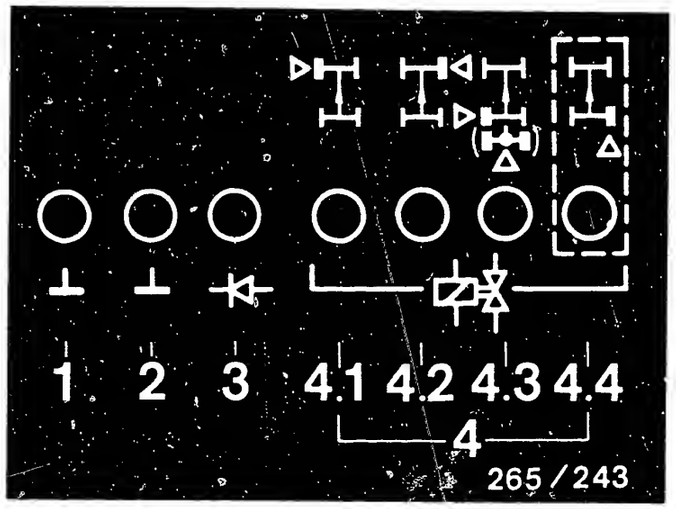
4 = LEDs for internal resistances of solenoid-operated valves in hydraulic modulator and off-position of valve relay

4.1 = LED for front left wheel

4.2 = LED for front right wheel

4.3 = LED for rear left wheel on vehicles with 4-channel hydraulic modulator or for rear axle on vehicles with 3-channel hydraulic modulator (symbol in parentheses valid)

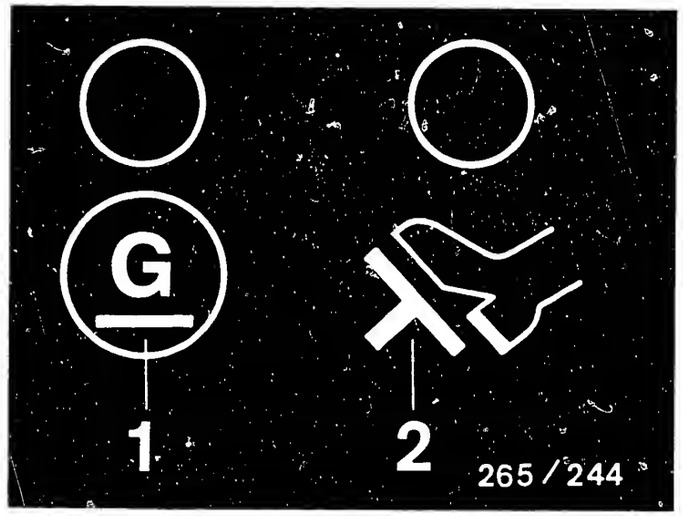
4.4 = LED for rear right wheel on vehicles with 4-channel hydraulic modulator.
The broken line indicates that the LED need light up only in the case of a 4-channel hydraulic modulator.



Program switch position 2 (Top diagram)

1 = LED for connection to alternator term. 61

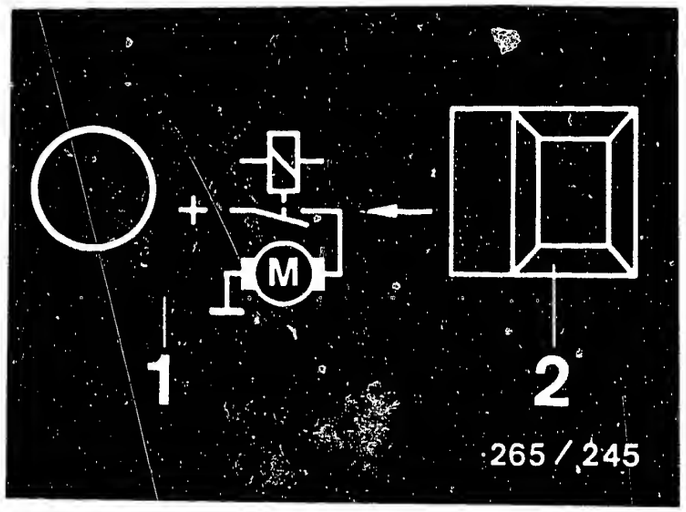
2 = LED for connection to stop-lamp switch



Program switch position 3 (Center diagram)

1 = LED for motor relay and return pump in hydraulic modulator

2 = Key for energization of motor relay
LED does not light up until after key has been pressed

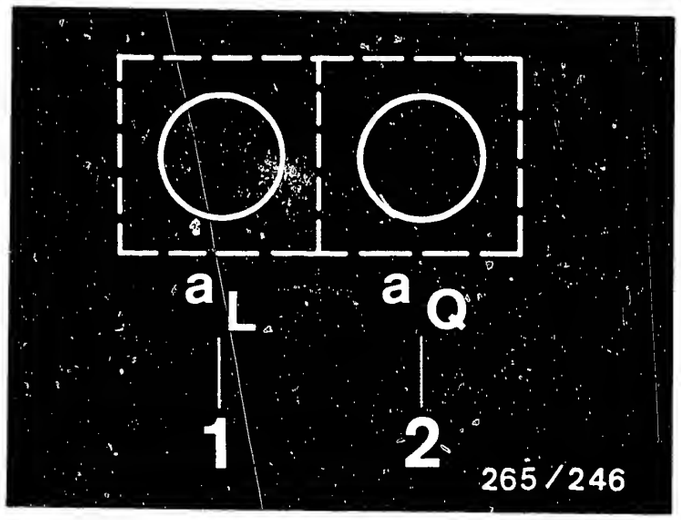


Program switch position 4 (Bottom diagram)

1 = LED for volume resistance of acceleration sensor longitudinal in forward direction of travel

2 = LED for volume resistance of acceleration sensor transverse to forward direction of travel

The dotted line indicates that the acceleration sensors are not installed in all vehicles.



Program switch position 5 (Top diagram)

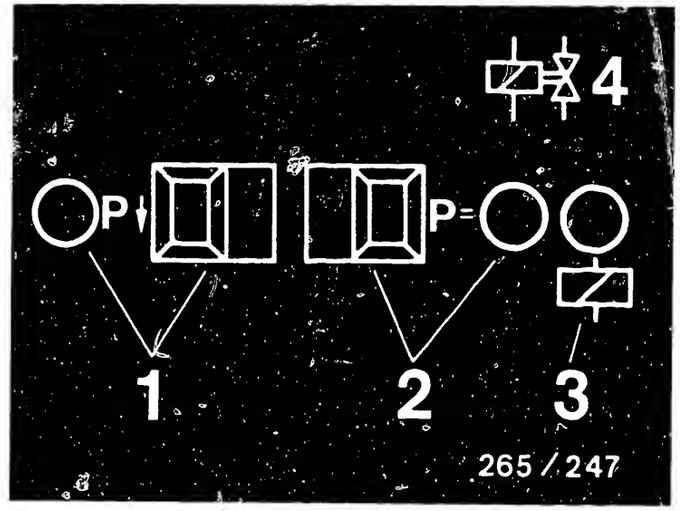
Functional tests of solenoid-operated valves and valve relay in hydraulic modulator.
Checking of channel assignment (identity check) of solenoid-operated valves.

1 = Key and LED for pressure-reduction function.
LED must come on after key is pressed.

2 = Key and LED for pressure-holding function.
LED must come on after key is pressed.

3 = LED for operation of valve relay.
LED must be constantly lit in program switch position 5.

4 = Symbol for solenoid-operated valves



Switch for wheel selection (Bottom diagram)

In program switch positions 5 and 6, the switch must be set to the wheel under test.

1 = Rotary switch for wheel selection

2 = Front left wheel

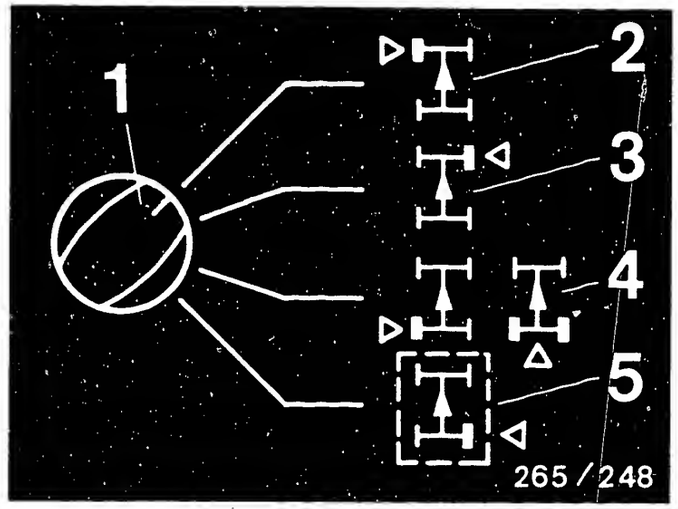
3 = Front right wheel

4 = Left symbol: Rear left wheel on vehicles with 4-channel hydraulic modulator (program switch position 5) or 4 wheel-speed sensors (program switch position 6).

Right symbol: Rear axle on vehicles with 3-channel hydraulic modulator or 3 wheel-speed sensors.

5 = Rear right wheel on vehicles with 4-channel hydraulic modulator or 4 wheel-speed sensors.

The broken line indicates that this switch position is not applicable for ABS systems with 3-channel hydraulic modulator or 3 wheel-speed sensors.

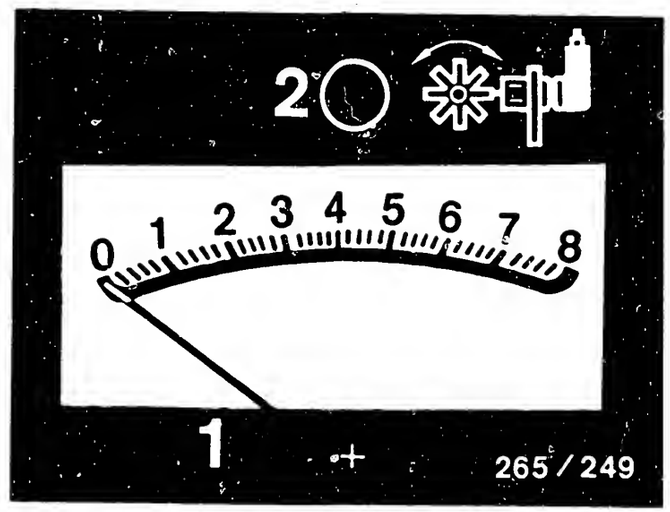


Program switch position 6 (Top diagram)

Testing of wheel-speed sensor signal and dynamic air-gap change between wheel-speed sensor and ring gear. Identity check of wheel-speed sensors.

1 = Pointer instrument

2 = LED for rotational movement of wheels.
LED is constantly lit if test speed is sufficient.
Only then make reading on instrument.



Connecting the tester

The ABS 2 LED tester is connected to the ABS wiring harness in the vehicle by means of an exchangeable adapter lead.
Switch off the ignition before disconnecting the ABS controller.

Testing

Switch on ignition for testing.

The vehicle-specific test charts should be taken from the table of contents.

REPLACING THE BRAKE FLUID

Caution when handling brake fluid:

a) Pour brake fluid only into containers in which there is no danger of drinking the fluid by mistake (warning: Poisonous!)
b) Even slight traces of mineral oil cause the brake system to fail. If the brake fluid is colorless or yellowish pay particular attention since in this case the danger of a mix-up is at its greatest. If mineral oil is detected in the brake system or if there is a suspicion of same, the entire brake system must be thoroughly rinsed with brake fluid. The brake master cylinder must also be replaced.
c) Do not allow brake fluid to come into contact with the vehicle paintwork as it contains components which dissolve paint.
d) Brake fluid is highly hygroscopic, i.e. it absorbs humidity thus reducing the boiling point. Thus, brake fluid may only be stored in thoroughly sealed containers.

Note:
In the course of its service life the boiling point of the brake fluid drops due to the continuous absorption of humidity from the atmosphere. Thus, vapor bubbles may form in the brake system if the brakes are subjected to extremely heavy braking conditions. The brake fluid must therefore be replaced annually, preferably in the spring.

Bleeding

- When using a bleeding device for bleeding, pay attention to the manufacturer's operating instructions. In order to eliminate all air bubbles from the tandem brake master cylinder, the brake pedal must be completely depressed at least three times during the bleeding process with the bleeder screws open.

- If bleeding is performed by "pumping" with the brake pedal, close the appropriate bleeder screw each time before releasing the brake pedal to prevent air from being sucked in via the thread of the bleeder screw.

- Slowly release brake pedal to ensure that sufficient brake fluid is sucked in from the fluid reservoir during the return stroke of the plunger.

- The bleeding process is complete when clear, bubble-free brake fluid emerges via the bleeder hose.

Important!
The brake fluid pumped out during bleeding may not be reused since it may contain foreign matter which would then get back into the brake system.

- Fill fluid reservoir with brake fluid as far as "max" mark.

GENERAL NOTES ON REPAIR WORK AND BRAKE SYSTEM

The ABS is basically maintenance-free, but when performing work on ABS-equipped vehicles, pay attention to the following:

1. If welding work is to be performed with an electric welding unit, the electronic controller plug must be removed.

2. During painting work the electronic controller may be subjected to a maximum of 95°C for brief periods and a maximum of 85°C for lengthy periods (approx. 2 hours).

3. After replacing the hydraulic modulator, the controller, the wheel-speed sensors and the wiring harness, as well as after work involving the ABS equipment (e.g. work after an accident), it is necessary to test the entire ABS system with the tester. Make sure that the brake lines are correctly laid.

4. After any work on the brake system, the brake system must be bled and high-pressure as well as low-pressure testing performed. All junctions are to be checked for leaks.

5. Tighten battery terminals correctly on the battery posts.

6. Do not use a fast charger for starting the engine.

7. Never disconnect the battery form the vehicle electrical system with engine running.

8. Disconnect the battery form the vehicle electrical system when fast charging.

9. Make sure that all connectors of the wiring harness are securely connected.

10. Never disconnect or connect the ABS wiring-harness plug from the controller with the ignition on.

11. For safety reasons, the hydraulic modulator must not be repaired, but the complete unit must be replaced. Exeptions to this are the return-pump relay and the valve relay. Both relays may be replaced.
No screws on the tydraulic modulator may be loosened apart from the brake-line connections. After loosening it is no longer possible to get the brake circuits leak-tight!
D a n g e r !

TEST CHART AND REPAIR INSTRUCTIONS FOR AUDI, BMW 5, 6 AND 7 SERIES AND LANCIA THEMA

Test conditions for testing with ABS 2 LED tester

- Correct size of tires mounted?
- Check ground connection of return pump and of overvoltage protection relay term. 31 for security and corrosion.
- Visually examine hydraulic connections and joints on hydraulic modulator for leaks.
- If the ABS warning lamp comes on occasionally while driving (e.g. after switching on loads) and goes out again by itself, check battery and power supply (alternator, regulator and voltage drops).
- If the ABS warning lamp is constantly lit and does not go out, check the following points:
  Multiple plug correctly seated on controller and latched?
  All plug contacts O.K.?
  Spring contacts latched?
  V-belt broken?
  (Alternator not supplying any voltage, charge indicator lamp and ABS warning lamp on).
  Check proper installation position of seal ring in controller plug:
  Curvature downwards.
  Check correct assignment of wheel-speed-sensor leads at controller plug.
  Front left wheel-speed sensor to term. 6 (BMW) or term. 5 (Lancia) and term. 4.
  Front right wheel-speed sensor to term. 21 and term. 23
  Rear left wheel-speed sensor to term. 7 and term. 9.

- To perform testing, switch on ignition in all program-selector switch settings (tester uses power supply from vehicle battery).

- Observe LED (green) for power supply in all program-selector switch settings.

- Connect ABS 2-LED tester to ABS wiring harness.

I M P O R T A N T !

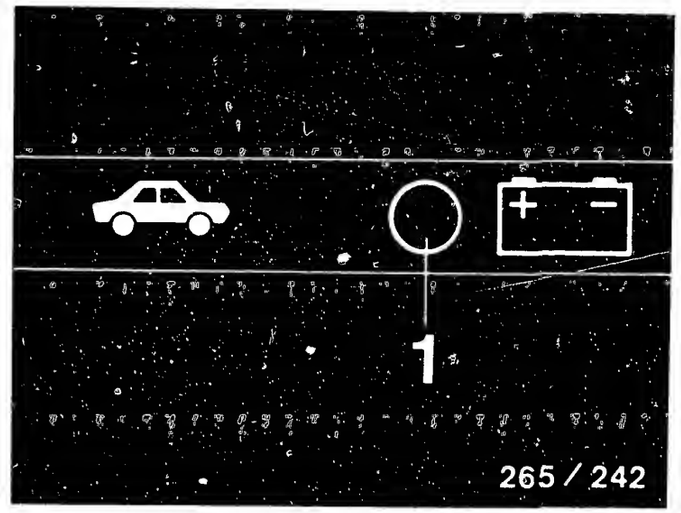
Only detach and attach controller with ignition switched off.
Never drive with tester connected!
The entire test program is to be repeated whenever repairs have been performed.
The antilock braking system is a vehicle safety system. Performing work on this system requires detailed system knowledge.
The conventional brake system must be in proper working order.

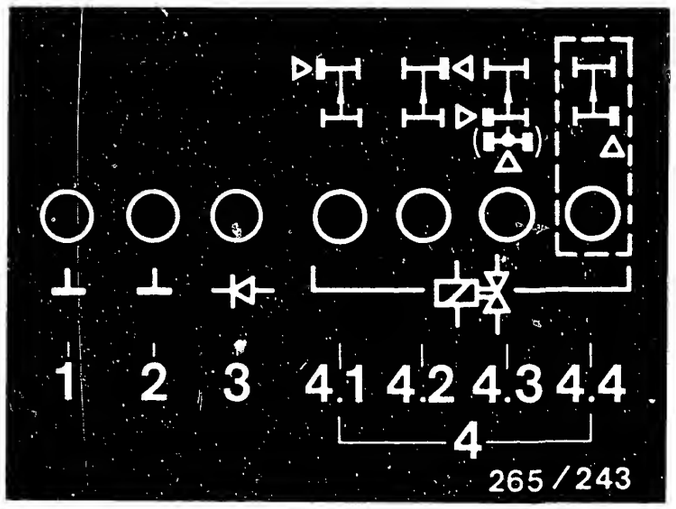
General information on trouble-shooting:

Test all leads for short-circuit to ground and contact with positive leads as well as for worn insulation and crushing.

Test chart for Audi 100, 200, BMW 5, 6, 7 series and Lancia Thema

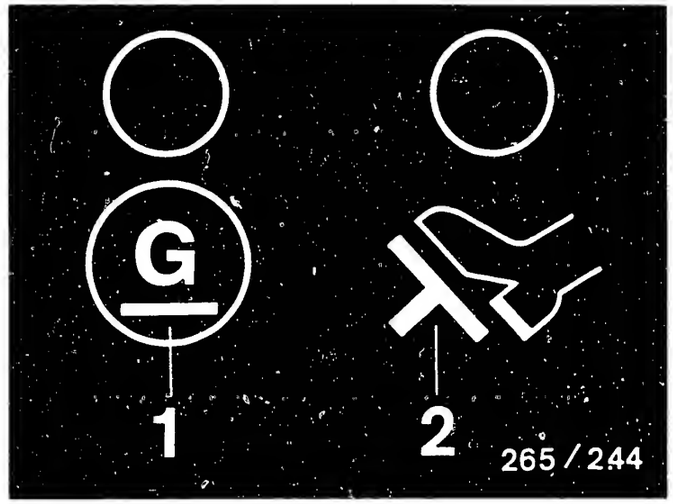
Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (reading)	Possible cause of trouble
all	Power supply (term. 20 and term. 1) for all test steps	Ignition on	LED (1) for battery voltage constantly lit (top diagram)	• Battery insufficiently charged • High voltage drops • Fuse defective • Overvoltage-protection relay defective • Check lead to ignition lock term. 15
1	Ground connections (term. 34, +erm. 10) Diode for warning lamp term. 29, term. 32); solenoid-valve internal resistances (term. 2, term. 35, term. 18, term. 19); off-position and ground connection of valve relay. ABS warning lamp.	Ignition on	7 LEDs (1, 2, 3, 4.1, 4.2, 4.3, 4.4) light up with uniform brightness (bottom picture) ABS warning lamp in vehicle must light up.	• LEDs (1,2) for ground connections do not light up: open-circuit in ground terminals • LED (3) for diode does not light up: diode defective. • LED (4.1, 4.2, 4.3 or 4.4) for solenoid valve does not light up: test corresponding plug connection for solenoid valve and leads. Solenoid-valve internal resistance 0.7 ... 1.7 Ω. • All LEDs (4) for solenoid valves and LED (3) for diode do not light up: test valve-relay ground connection, valve relay defective. • ABS warning lamp does not light up: warning lamp defective. Note: the other 6 LEDs light up.

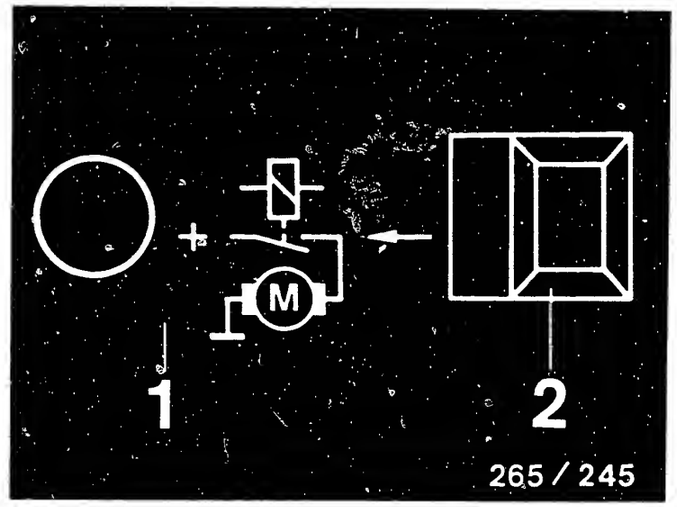




Test chart for Audi 100, 200, BMW 5, 6, 7 series and Lancia Thema

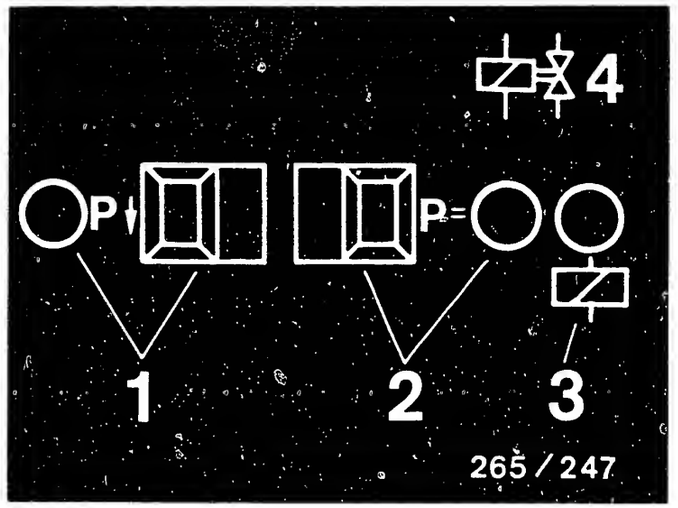
Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (reading)	Possible cause of trouble
2	Alternator voltage from term. 61 (term. 15) (Audi, BMW: if there is a lead to term. 15)	Ignition on	LED (1) for alternator lit (top diagram)	• In some cases, LED (1) only goes out after burst of throttle (test is then O.K.) • Check lead to alternator term. 61 • Alternator defective
		Start engine	LED (1) goes out when engine running	
	Stop-lamp switch (term. 25). BMW 5,6 and 7 series as of generation 2 B (i.e. if there is a lead to term. 25)	Igrition on	LED (2) for stop-lamp switch lit	• Check lead to stop-lamp switch • Stop-lamp switch defective • Lead incorrectly connected to stop-lamp switch.
		Press brake pedal	LED (2) goes out	
3	Motor relay, pump motor in hydraulic modulator (term. 28)	Ignition on Press key (2) continuously	LED (1) lit, pump motor operating (bottom diagram)	Note: After releasing the key, LED (1) continues to light due to running-down of motor • Motor relay defective • Check ground connection of hydraulic modulator • Pump motor defective.

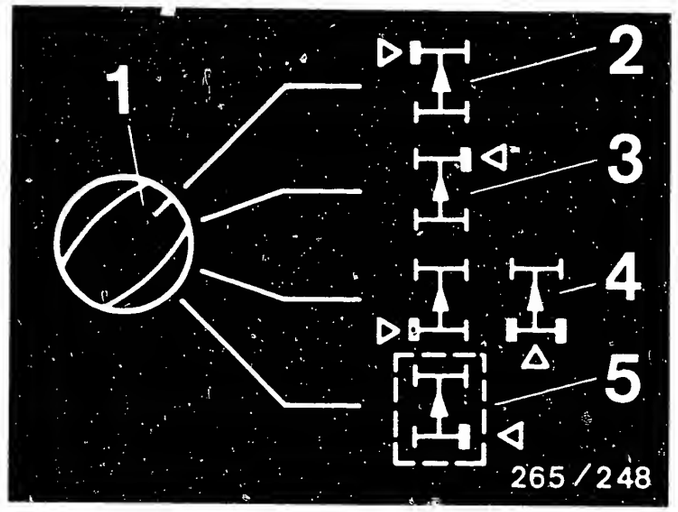




Test chart for Audi 100, 200, BMW 5, 6, 7 series and Lancia Thema

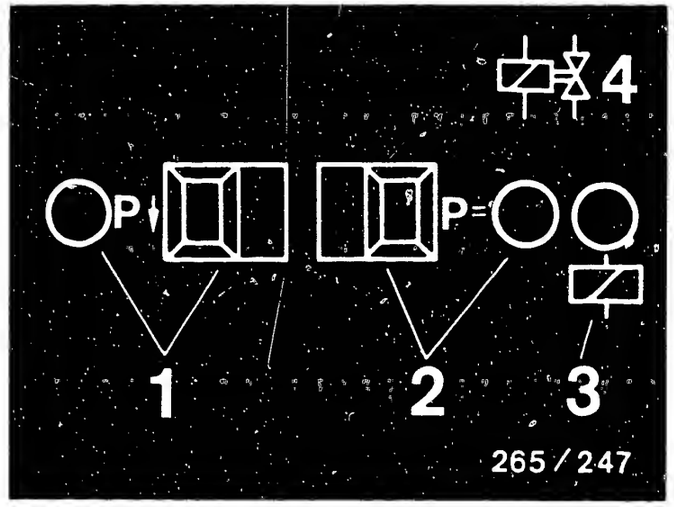
Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (reading)	Possible cause of trouble
4	Longitudinal acceleration sensor a_L (term.16) and transverse acceleration sensor a_Q (term.13)	Ignition on	not applicable	-----
5	Valve relay - operation (term. 27)	Ignition on	LED (3) for valve relay lit (top diagram)	• Test valve relay and leads to term. 85 and term. 86.
	Functional test and identity check of solenoid-operated valves in hydraulic modulator. Note: Perform test separately for each wheel one after the other.	Raise vehicle. Ignition on. The wheel under test must be freely rotatable by hand. Set wheel-selection switch to wheel under test (Items 2, 3, 4 and 5) (bottom diagram). Keep to sequence of operations.		





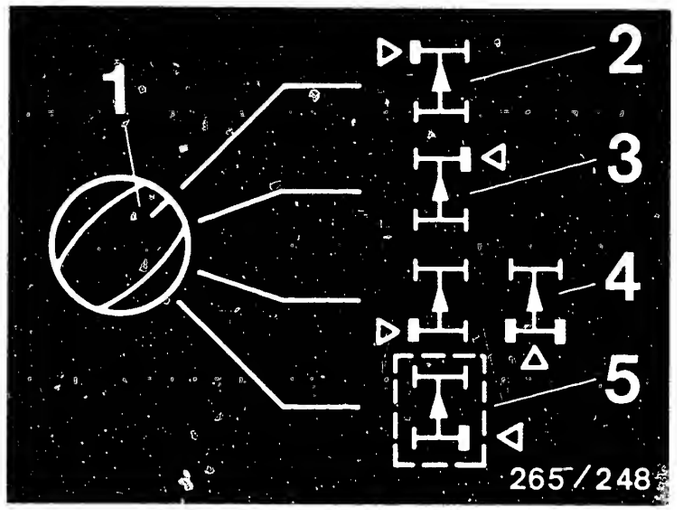
Test chart for Audi 100, 200, BMW 5, 6, 7 series and Lancia Thema

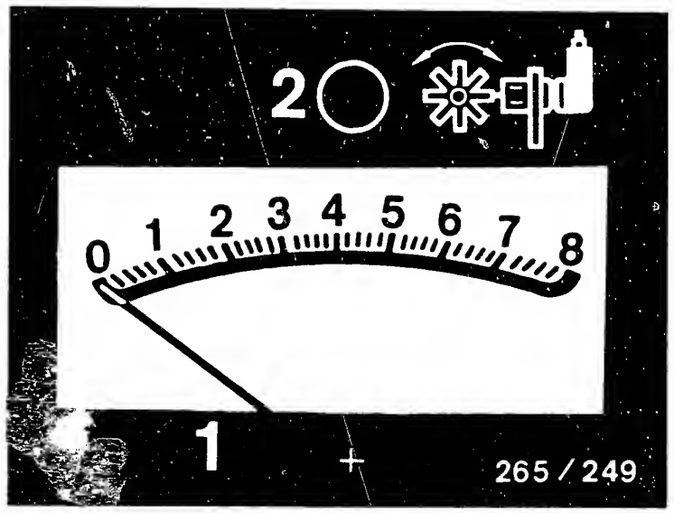
Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (reading)	Possible cause of trouble
5 (continued)	Pressure holding function	1. Press key P = (2) continuously	LED P = (2) lit (top diagram)	• Battery voltage too low: repeat test with engine running. • Valve relay defective, • open-circuit in lead from valve relay, term. 87 to B+, • brake lines mixed up at hydraulic modulator, • current value is not obtained (LED for pressure hold or pressure reduction goes out) because the battery is inadequately charged: repeat test with engine running. • Hydraulic modulator defective.
		2. Press brake pedal continuously	Wheel under test rotatable by hand	
		3. Release key P=(2)	LED P= (2) goes out, wheel locks	
	Pressure reduction function	4. Press key P (1) for pressure reduction	LED (1) for pressure reduction lit, wheel rotatable by hand	
		5. Release key P (1) for pressure reduction	LED (1) for pressure reduction goes out, wheel locks	
		6. Release brake pedal		



Test chart for Audi 100, 200, BMW 5, 6, 7 series and Lancia Thema

Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (reading)	Possible cause of trouble
6	Functional test and identity check of wheel-speed sensors. Note: Perform test separately for each wheel one after the other. Front left wheel: BMW 5, 6, 7 series: term. 6 and term. 4 Audi 100, 200, Lancia Thema: term. 4 and term. 5 Front right wheel: BMW 5, 6, 7 series, Audi 100, 200 Lancia Thema: term. 21 and term. 23 Rear left wheel: BMW 5, 6, 7 series, Audi 100, 200, Lancia Thema: term. 7 and term. 9 Rear right wheel: BMW 5, 6, 7 series, Audi 100, 200, Lancia Thema: term. 24 and 26	Raise vehicle: Ignition on. The wheel under test must be freely rotatable by hand. Set wheel-selection switch (top diagram) to the wheel under test (Items 2, 3, 4, 5 in top diagram) Turn wheel by hand until LED (No. 2, bottom diagram) above the instrument lights up without flickering (at approx. 1 revolution per second). Make reading on instrument.	Lowest reading greater than 1.0 scale graduations. Allowable width of variation: max. 25 % of highest reading.	• Wheel-speed sensor lead mixed up • Open circuit in wheel-speed sensor lead • Wheel-speed sensor defective, winding resistance: Audi 100, 200, BMW 5, 6, 7 series 9.81 → (RA) 0.8 ... 1.8 kΩ BMW 7 series → 8.80 (FA + RA) BMW 5, 6 series (FA) BMW 7 series, Lancia Thema: 0.6 ... 1.6 kΩ • Air gap between wheel-speed sensor and ring gear too great • Ring gear defective or loose • Ring gear with incorrect number of teeth installed. 96 teeth. Exception: Lancia Thema 90 teeth. • Wheel-bearing play too great





Finally, perform a road test. With engine running, the warning lamp must go out. In some cases, the warning lamp goes out only as of 6 km/h. Drive at at least 30 km/h. The warning lamp must not come on again.

Repair instructions for wheel-speed sensors

Removing the wheel-speed sensors on the front axle:

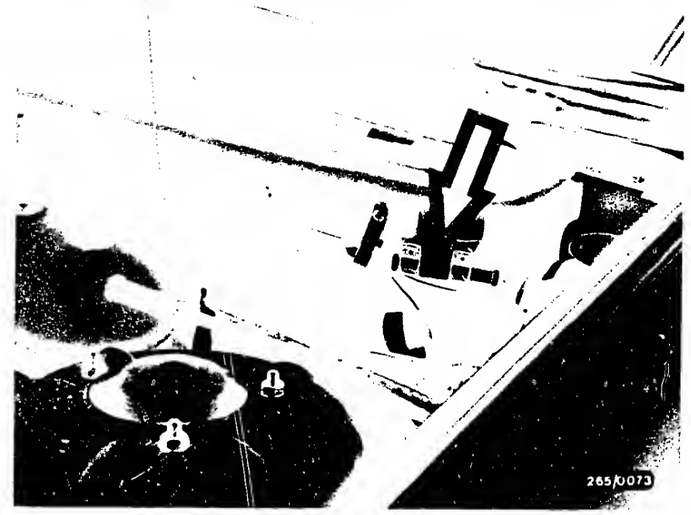
- Switch off ignition.
- Take apart plug connector (top picture - arrow) in engine compartment.
- Release wheel-speed sensor lead from fastening points.
- Loosen fastening screw (2) and pull out wheel-speed sensor.
  Do not use force.

Installing the wheel-speed sensors on the front axle:

- Check O-ring for cracks, replace if necessary.
  Audi:
  Replace plastic tip on wheel-speed sensor edge.
  Ensure correct seating.
- Grease wheel-speed sensor housing with Molykote Longterm 2.

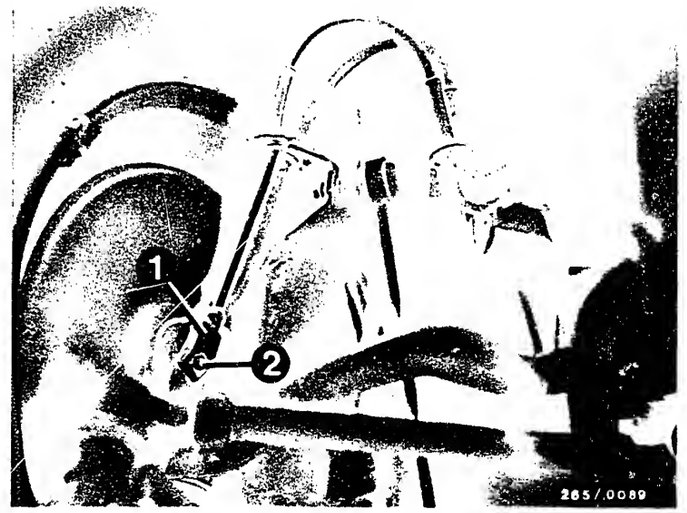
  Caution:
  Before installing the wheel-speed sensors, make sure that there are no metallic foreign bodies on the permanently magnetic edges.
- Press wheel-speed sensor into mounting hole. Do not knock.
  Do not damage O-ring.
- Secure wheel-speed sensor with new micro-encapsulated screws.
- Re-attach wheel-speed sensor lead at the points provided.

Audi:
- Carefully press wheel-speed sensor into mounting hole until it comes up against ring gear. Do not knock. Air gap is correctly set by the plastic tip.
- Use new micro-encapsulated fastening screw. Tighten fastening screw to 6 ... 8 Nm.
  When tightening, press wheel-speed sensor into hole by hand. This prevents the wheel-speed sensor lifting off the ring gear and the air gap becoming too great.



Arrow = Wheel-speed sensor plug connector in engine compartment

1 = Wheel-speed sensor
2 = Hexagon-socket-head cap screw



Repair instructions for wheel-speed sensors (continued)

Removing the wheel-speed sensors on the rear axle

- BMW 6 series:

  The rear wheels can be removed in order to facilitate replacement of the wheel-speed sensors.
- Switch off ignition.
- Take apart wheel-speed sensor plug connector.
- Release wheel-speed sensor lead from fastening points.
- Loosen fastening screw (3) and pull out wheel-speed sensor. Do not use force.

- BMW 6 series:

  Unscrew brake caliper so that wheel-speed sensor can be pulled out. Brake line remains connected.

- BMW 7 series:

  If applicable, do not lose or mix up shim rings (4) of the two rear-axle wheel-speed sensors. Different thicknesses possible.

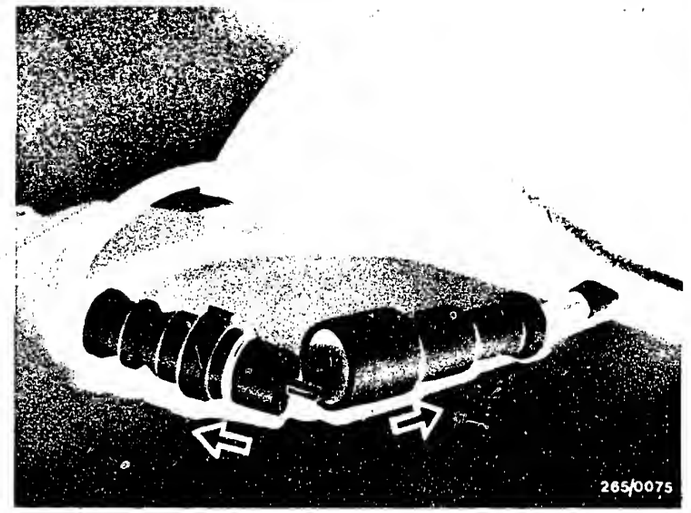
Installing the wheel-speed sensors on the rear axle

- Check O-ring for cracks and replace if necessary.

  Audi:
  Replace plastic tip on wheel-speed sensor edge. Ensure correct seating.
- Grease wheel-speed sensor housing with Molykote Longterm 2.

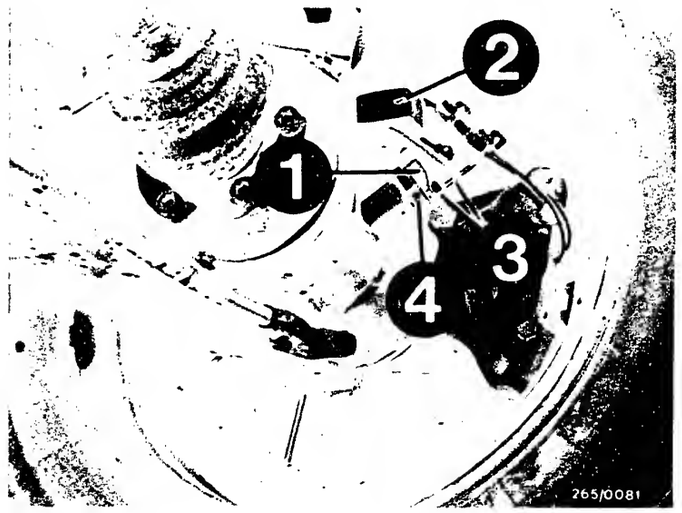
Caution:

Before installing the wheel-speed sensors, make sure that there are no metallic foreign bodies on the permanently magnetic edges.



Arrows = Wheel-speed sensor plug connector under rear seat (BMW 7 series)

1 = Wheel-speed sensor (BMW 7 series)
2 = Rubber sleeve
3 = Hexagon-socket-head cap screw
4 = Shim ring



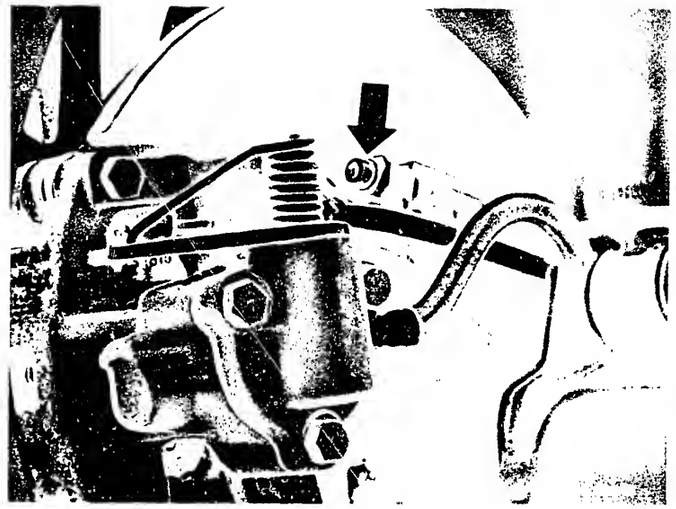
Repair instructions for wheel-speed sensors (continued)

Installing the wheel-speed sensors on the rear axle (continued)

- Press wheel-speed sensor into mounting hole; do not knock. Do not damage O-ring.
- Secure wheel-speed sensors with new micro-encapsulated screws.
- Re-attach wheel-speed sensor lead at the points provided.

Audi:

- Carefully press wheel-speed sensor into mounting hole until it comes up against ring gear. Do not knock. Air gap is correctly set by the plastic tip.
- Use new micro-encapsulated fastening screw. Tighten fastening screw to 6 ... 8 Nm.
  When tightening, press wheel-speed sensor into hole by hand. This prevents the wheel-speed sensor lifting off the ring gear and the air gap becoming too great.



Arrow = Fastening screw for wheel-speed sensor (Audi)

BMW 6 series:

- Re-mount brake caliper and rear wheel.

BMW 7 series:

- Notes on wheel-speed sensors with shim rings:

  If re-using the same wheel-speed sensors, make sure that shim rings of left-hand and right-hand wheel-speed sensors are not mixed up.

  Before installing a new wheel-speed sensor, take shim ring of correct dimensions. Max. air gap 0.8 mm.

  Do not install wheel-speed sensors without shim rings; danger of damaging.

1 = Wheel-speed sensor (BMW 6 series)
2 = Hexagon-socket-head cap screw

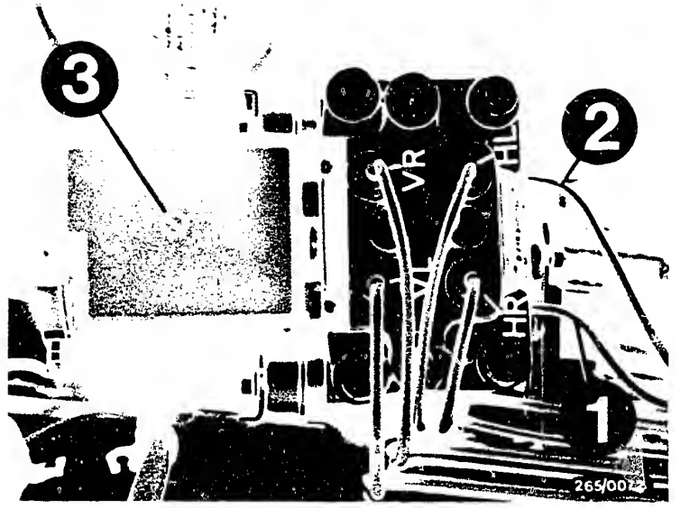
Repair instructions for hydraulic modulators

Removing the hydraulic modulator

- For safety reasons, the hydraulic modulator must not be repaired, but the complete unit must be replaced.
  Exceptions to this are the return-pump relay and the valve relay. Both relays may be replaced.

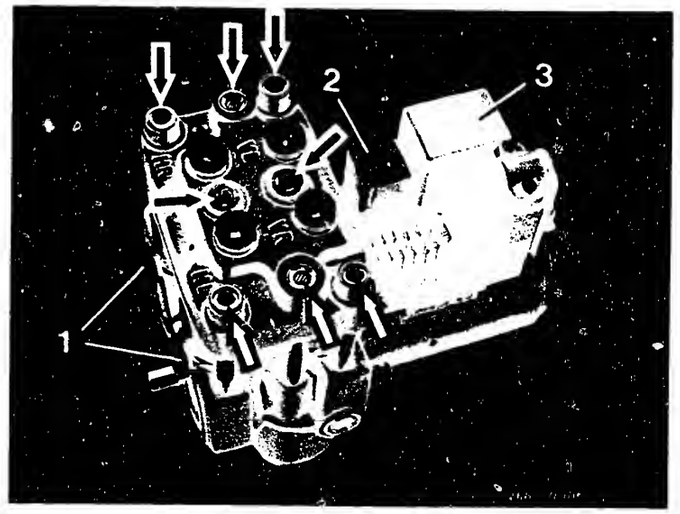
- Apart from the brake-line connections, it is not permissible to loosen any screws on the hydraulic modulator. In particular the hexagon-socket-head cap screws (bottom picture - arrows) may under no circumstances be loosened. After loosening, it is no longer possible to get the brake circuits leak-tight.
  Danger!

- Check the hydraulic modulator and brake-line connections for leaks by means of a visual examination. If brake fluid is escaping, tighten the brake-line connections (12...16 Nm) or replace, or replace the hydraulic modulator.



1 = Brake line to front brake master cylinder
2 = Brake line to rear brake master cylinder
3 = Screw for lid

1 = Connection points for brake lines to brake master cylinder
2 = Valve relay
3 = Return-pump relay



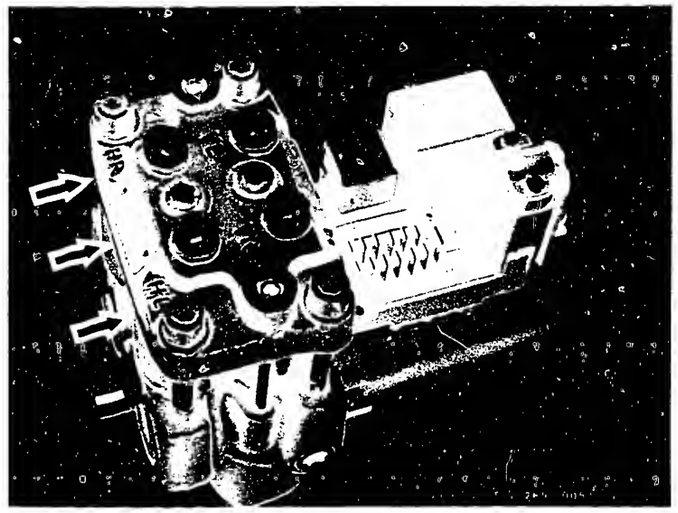
Repair instructions for hydraulic modulators (continued)

Pay particular attention to the joint identified by 3 arrows (top picture). On the base of the hydraulic modulator there is a vent hole to the pump pistons. A slight escape of brake fluid is possible at this point.
A complaint is only justified if, after pressing the brake pedal several times, a pool of brake fluid is formed under the hydraulic modulator.

- When removing and installing the brake lines, make sure that the lines are marked in accordance with the markings on the hydraulic modulator and that they are not mixed up when re-connecting (e.g. FL of hydraulic modulator must be connected to the front left wheel brake cylinder).

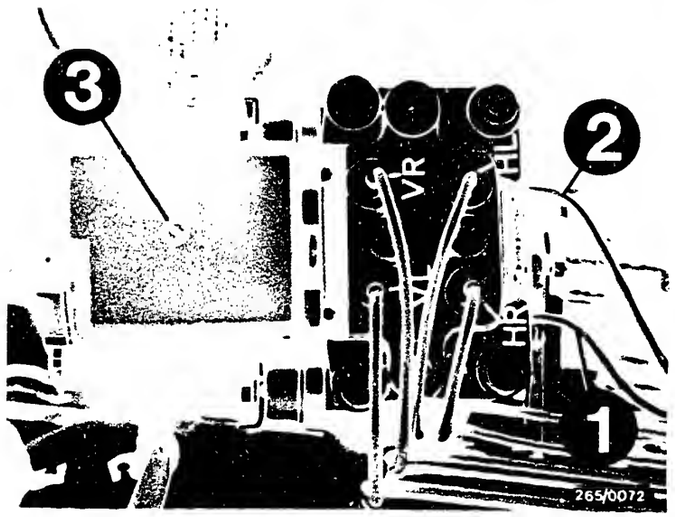
- Markings on hydraulic modulator

VL = Connection for brake line front left (wheel brake cylinder)
VR = Connection for brake line front right (wheel brake cylinder)
HR = Connection for brake line rear right (wheel brake cylinder)
HL = Connection for brake line rear left (wheel brake cylinder)



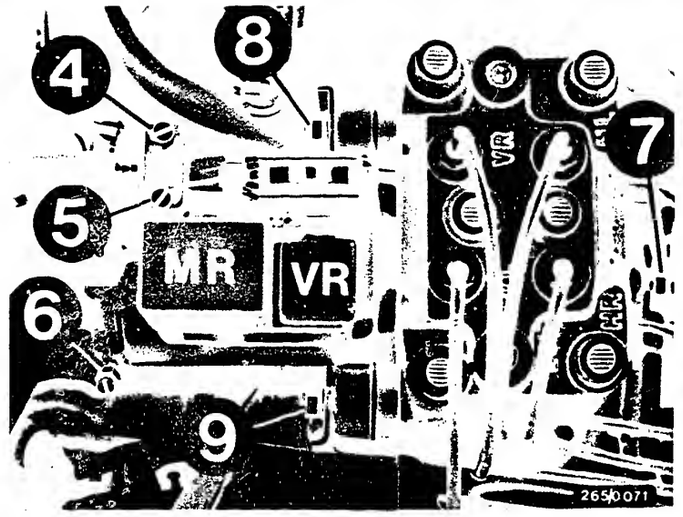
Arrows = Joint

1 = Brake line to front brake master cylinder
2 = Brake line to rear brake master cylinder
3 = Screw for lid



Repair instructions for hydraulic modulators (continued)

- Use only the specified double-end flare nut wrench 9x11 mm for loosening and tightening the brake lines.
- Mark brake lines and remove from hydraulic modulator.
- Catch the brake fluid and do not bring it into contact with your skin or clothing or with paintwork.
- Immediately seal the brake lines and connections with dummy plugs.
- Disconnect ground cable (6) from pump motor.
- Loosen fastening screw and remove cover.
- Loosen bracket (4, 5) and remove plug.
- Loosen hexagon nuts from holder (7,8,9) and remove hydraulic modulator.

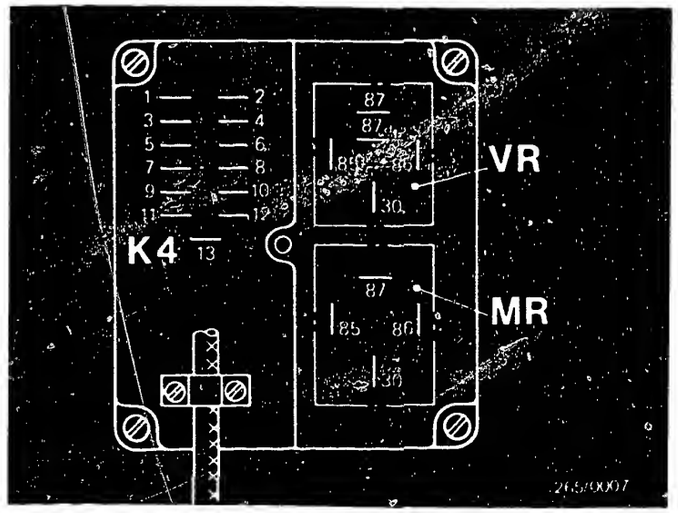


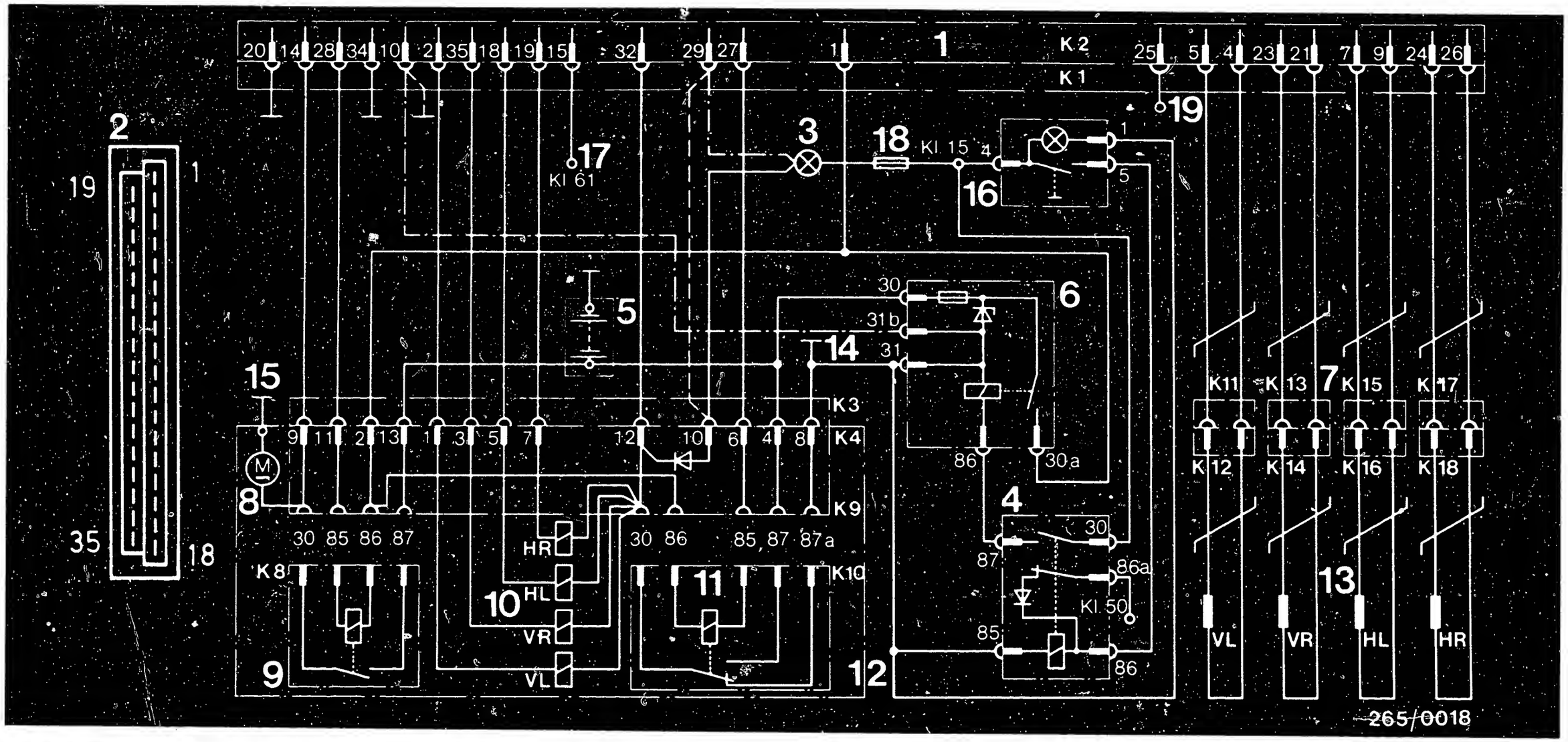
Installation

- Mount hydraulic modulator in the holder and fasten with the hexagon nuts.
- Connect ground cable to pump motor. Plug on 13-pin plug and fasten with the bracket (4,5).
- Fasten cover on the hydraulic modulator with the screw.
- Connect the brake lines to the hydraulic modulator in accordance with the markings.
- Observe the tightening torque for the brake-line connections on the hydraulic modulator: 12...16 Nm.
- Bleed the brake system and check for leaks.
- Fully test the ABS with the tester.
- Completely check ABS with tester.

6 = Ground terminal for pump motor
7,8+9 = Fastening points for hydraulic modulator
MR = Motor relay
VR = Valve relay

Hydraulic modulator plug-in plate
Position of terminals:
VR = Valve relay
MR = Motor relay
K4 = Wiring-harness plug



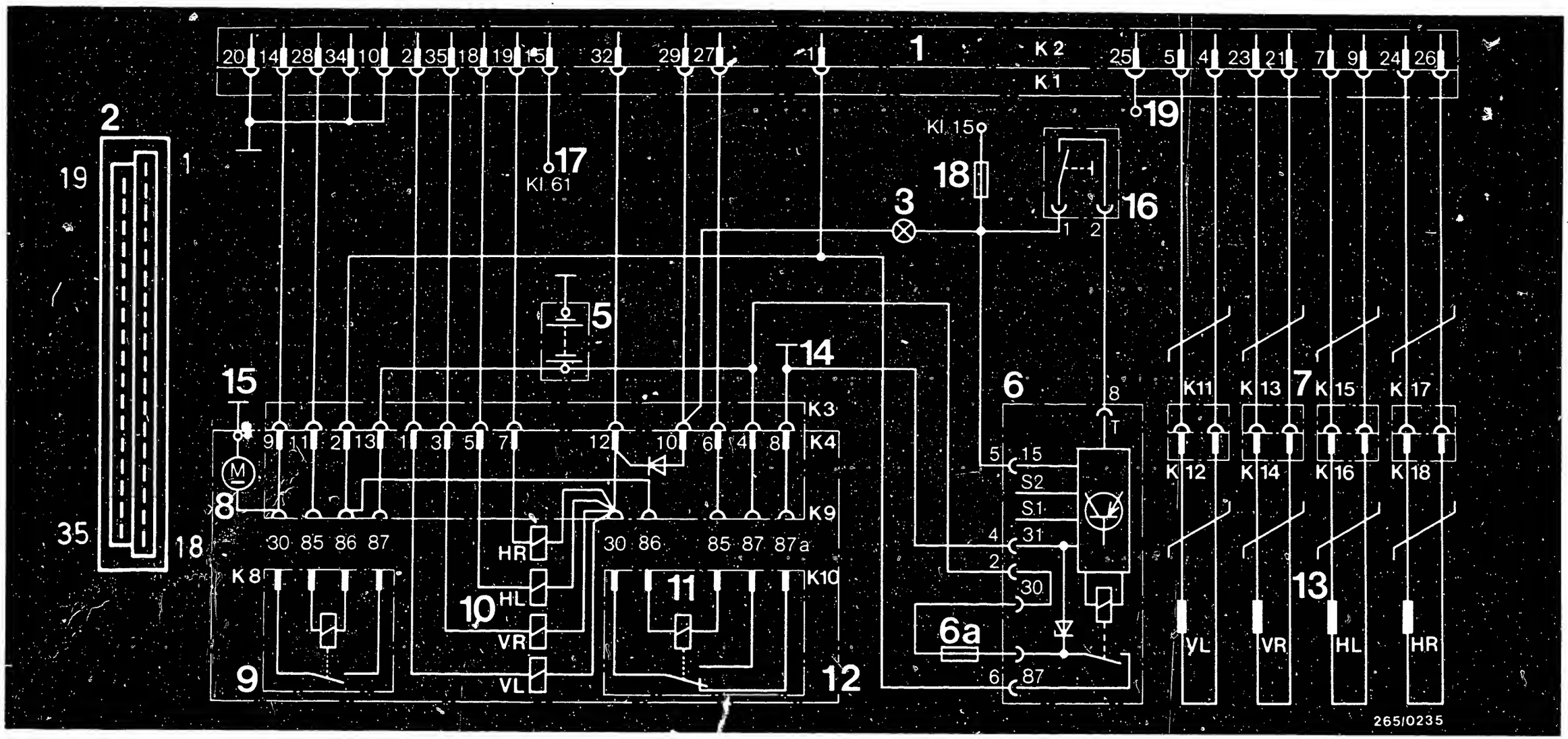


1 = Controller
2 = Multiple plug (35-pin)
3 = ABS warning lamp
4 = Relay for controller (step-by-step relay)
5 = Battery
6 = Overvoltage protection relay
7 = Cable connector
8 = Return-pump motor
9 = Return-pump relay
10 = Solenoid-operated valves
11 = Valve relay
12 = Hydraulic modulator
13 = Wheel-speed sensor
14 = Ground terminal behind switchboard
15 = Ground terminal - engine compartment on left
16 = ABS switch
------- = valid as of 9.83
-.-.-.- = not applicable as of 9.83
17 = If there is a lead to the alternator
18 = Fuse in relay board with fuse holder
19 = To stop-lamp switch (as of generation 2 B, i.e. if there is a lead to term. 25)

VL = Front left
VR = Front right
HL = Rear left
HR = Rear right

K 1, K 2 etc. = plug numbers

ELECTRICAL TERMINAL DIAGRAM FOR AUDI 100 (9.82→8.83); 200 (8.80→8.83); 200 (9.83→7.84)



1 = Controller
2 = Multiple plug (35-pin)
3 = ABS warning lamp
5 = Battery
6 = Combined relay
6a = Fuse (10 A) in combined relay
7 = Cable connector
8 = Return-pump motor
9 = Motor relay
10 = Solenoid-op. valves
11 = Valve relay
12 = Hydraulic modulator
13 = Wheel-speed sensor
14 = Ground terminal behind instrument panel
15 = Ground terminal, on left in engine compartment
16 = ABS switch
17 = to alternator
18 = Fuse in relay board
19 = to stop-lamp switch

VL = Front left
VR = Front right
HL = Rear left
HR = Rear right
K1,
K2
etc.= Plug numbers

Electrical terminal diagram for Audi models with two-wheel drive as of 8.84 (with combi relay), type 80, 90 → 12.87, type 100, 200 → 6.87

Installation position of components in Audi 100 / 200

The indications "left" and "right" apply always as viewed in the forward direction of travel.

- ABS warning lamp:
  In instrument panel.

- ABS switch:
  In instrument panel.

- Front-axle wheel-speed sensors:
  One each on left and right in the steering knuckles.

- Wheel-speed sensor plug connectors:
  In engine compartment, on left and right on body.

- Rear-axle wheel-speed sensors:
  One each on left and right near brake calipers.

- Wheel-speed sensor plug connectors:
  Under rear seat bench.

- Hydraulic modulator:
  In engine compartment on left in front of brake master cylinder.

- Ground terminal for ABS:
  On hydraulic modulator mounting.

- Controller:
  Audi 100 and Audi 200 (as of 9.83):
  On left under rear seat bench.

  Audi 200 (up to 8.83):
  Under glove compartment.

  Audi 80 and 90:
  In luggage compartment on left.

- Relay for controller (up to 7.84):

  On left under instrument panel.

  Audi 100 (up to 8.83):
  Relay location 8;

  Audi 100 and 200 (as of 9.83):
  Relay location 7.

- Overvoltage-protection relay (up to 7.84):

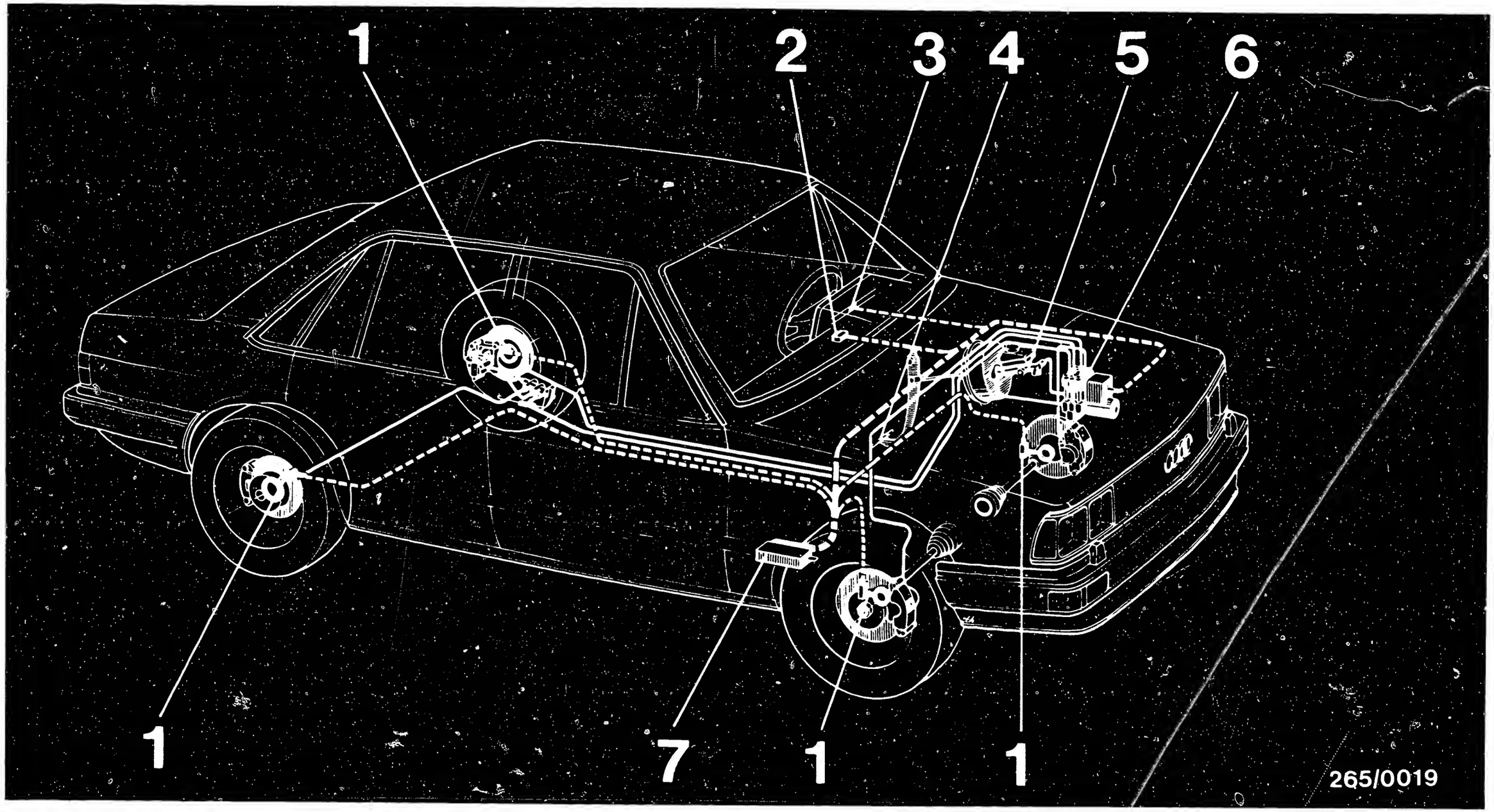
  Audi 200 (up to 8.83):
  On right under glove compartment, mounted on controller.

  Audi 100 (up to 8.83):
  Relay location 7.

  Audi 100 and 200 (as of 9.83):
  Relay location 11.

- Combined relay:

  (Successor relay to overvoltage-protection relay and relay for controller) as of 8.84 for all models:
  On auxiliary relay carrier on left under instrument panel, relay location 5.



1 = 4 wheel-speed sensors on the wheels
2 = ABS switch
3 = Indicator lamp in instrument panel
4 = Brake pedal
5 = Brake master cylinder
6 = Hydraulic modulator in engine compartment
7 = Controller: Audi 100 and Audi 200 (as of 9.83): under rear seat bench on left. Audi 200: under glove compartment

Audi 200 up to 8.83:
Under glove compartment
Audi 80 and 90:
In luggage compartment on left
----- = Electric leads
——— = Hydraulic lines

Installation position of components in Audi 100 / 200 (Audi 80 and 90 similar)

Checking the brake system for leaks

	High-pressure test	Low-pressure test
Line test pressure Gauge pressure	50 bar	3 bar
Test duration	45 seconds	3 minutes
Pressure drop of set value	4 bar (max.)	1 bar (max.)

Note
The leakage check, which must be performed in both brake circuits, comprises high-pressure and low-pressure testing.

High-pressure test

- Connect pressure tester to fixed caliper. To do this, unscrew bleeder screw and screw in fitting. Then bleed pressure tester.

- Allow engine to run at medium speed and generate as high a vacuum as possible by suddenly releasing the accelerator pedal.

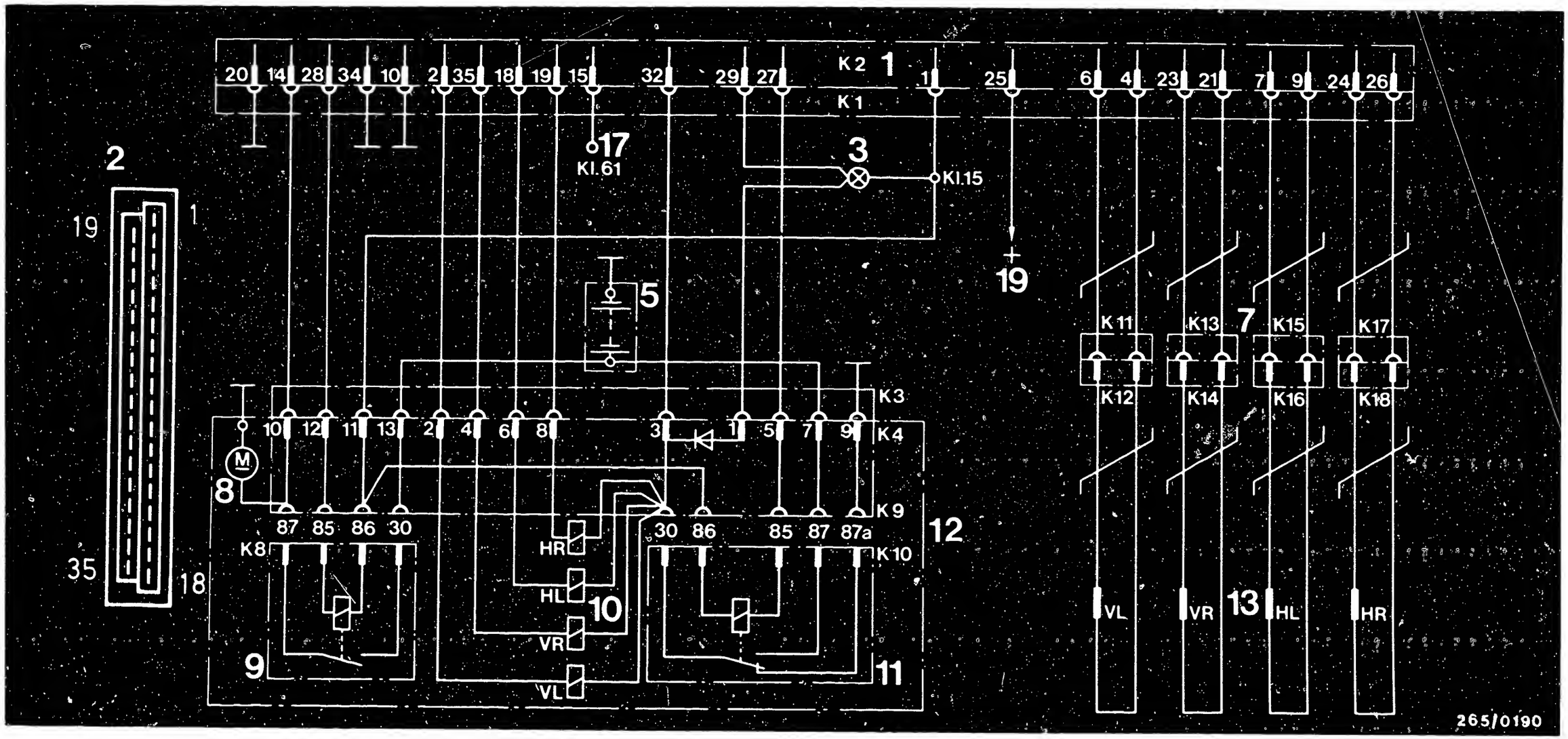
- Using the brake-pedal actuating device, press in brake pedal until a line pressure of 50 bar gauge pressure is produced. Then hold brake pedal in this position.

- During the test duration of 45 seconds the pressure drop must not be greater than 4 bar. If there is a greater pressure drop, the leak (brake master cylinder, brake hoses, brake pipes, brake caliper) must be found and remedied, or the hydraulic modulator must be replaced.

Low-pressure test

- Release brake pedal actuating device until a line pressure of 6 bar gauge pressure is indicated on the pressure gauge.

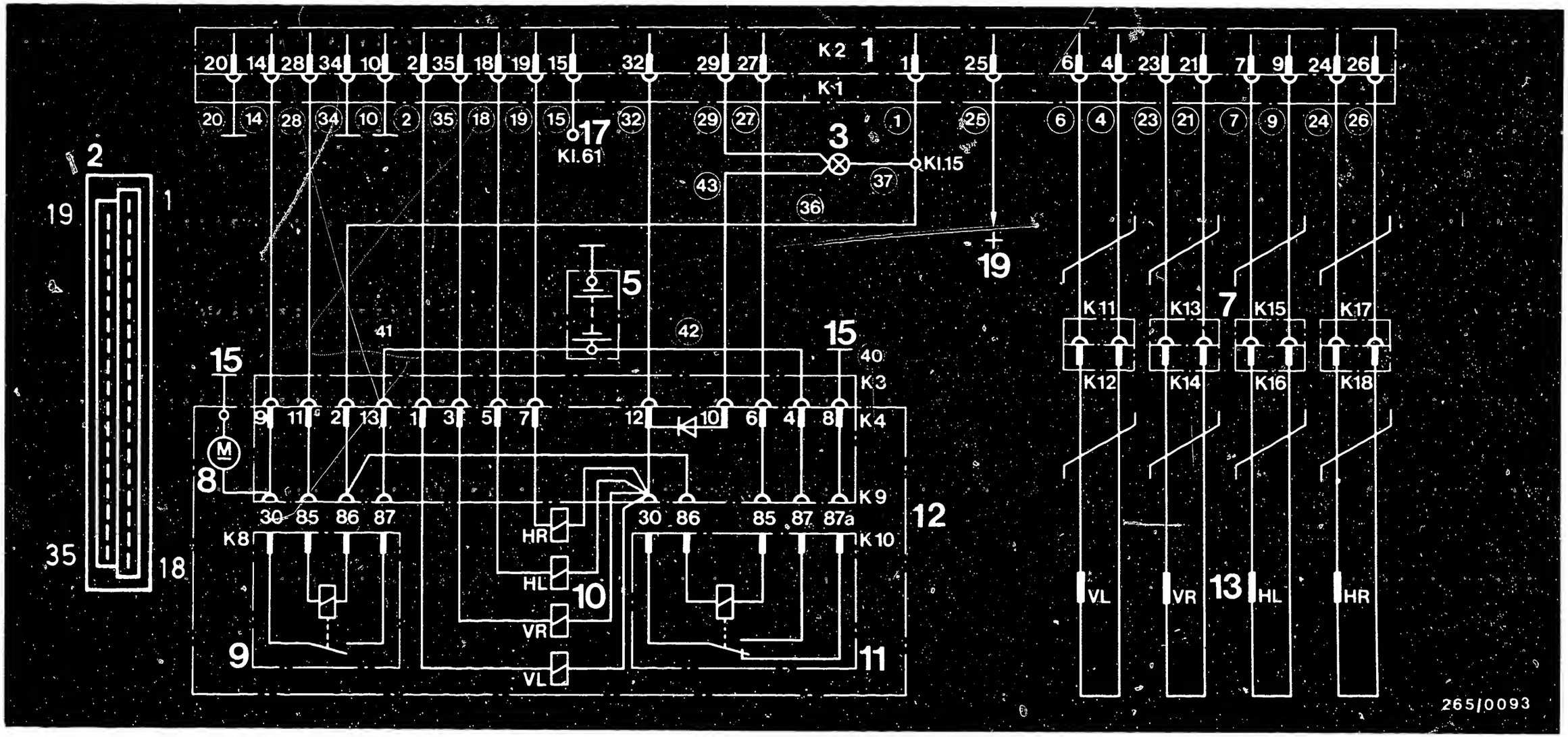
- During a test duration of 3 minutes the set pressure must not drop more than 1 bar. If there is a greater pressure drop, the leak must be found and remedied, and the brake master cylinder or the hydraulic modulator must be replaced.



1 = Controller
2 = Multiple plug (35-pin)
3 = ABS warning lamp
5 = Battery
7 = Plug connectors
8 = Return-pump motor
9 = Motor relay
10 = Solenoid-operated valve
11 = Valve relay
12 = Hydraulic modulator
13 = Wheel-speed sensor
17 = if there is a lead to the alternator
19 = to stop-lamp switch (as of generation 2 B, i.e. if there is a lead to term. 25)

VL = Front left
VR = Front right
HL = Rear left
HR = Rear right
K1, K2 etc. = Plug numbers

ELECTRICAL TERMINAL DIAGRAM FOR BMW 5 SERIES MODELS (E 28) → 12.87



1 = Controller
2 = Multiple plug (35-pin)
3 = ABS warning lamp
5 = Battery
7 = Plug-in connectors
8 = Return-pump motor
9 = Return-pump relay
10= Solenoid-operated valves
11 = Valve relay
12 = Hydraulic modulator
13 = Wheel-speed sensor
15 = Ground terminal in engine compartment on front left
17 = If there is a lead to the alternator
19 = To stop-lamp switch (as of generation 2 B, i.e. if there is a lead to term. 25)

VL = Front left
VR = Front right
HL = Rear left
HR = Rear right

K1, K2 etc. = Connector numbers

ELECTRICAL TERMINAL DIAGRAM FOR BMW 6 AND 7 SERIES MODELS (→ 8.86)

Installation position of components in BMW 5, 6, 7 series models

The indications "left" and "right" apply always as viewed in the forward direction of travel.

- ABS warning lamp:
  In instrument panel

- Front-axle wheel-speed sensors:
  One each on left and right in the steering knuckles.

- Wheel-speed sensor plug connectors:
  In engine compartment on left and right on body.

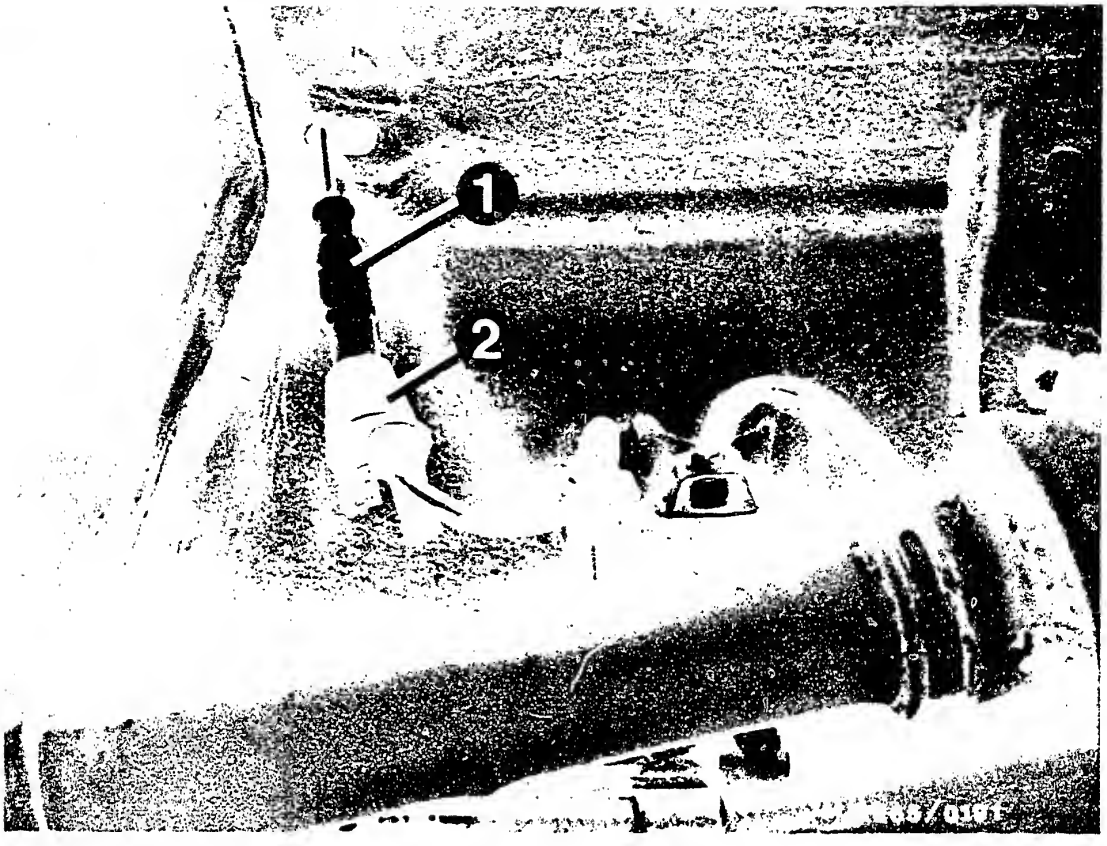
- Rear-axle wheel-speed sensors:
  One each on left and right near brake calipers.

- Wheel-speed sensor plug connectors:
  5 and 6 series: Under vehicle on left and right in floor panel
  7 series: Under rear seat bench

- Hydraulic modulator:
  5 series: In engine compartment behind right-hand headlamp.
  6 and 7 series: In engine compartment on left in front of brake master cylinder.

- Ground terminal for ABS:
  5 and 6 series: In engine compartment, front left, near battery.
  7 series: Under fuse box.

- Controller:
  5 series: In glove compartment behind cover. If applicable, remove Jetronic control unit.
  6 series: In equipment space in front of engine-compartment firewall.
  7 series: In glove compartment behind cover.



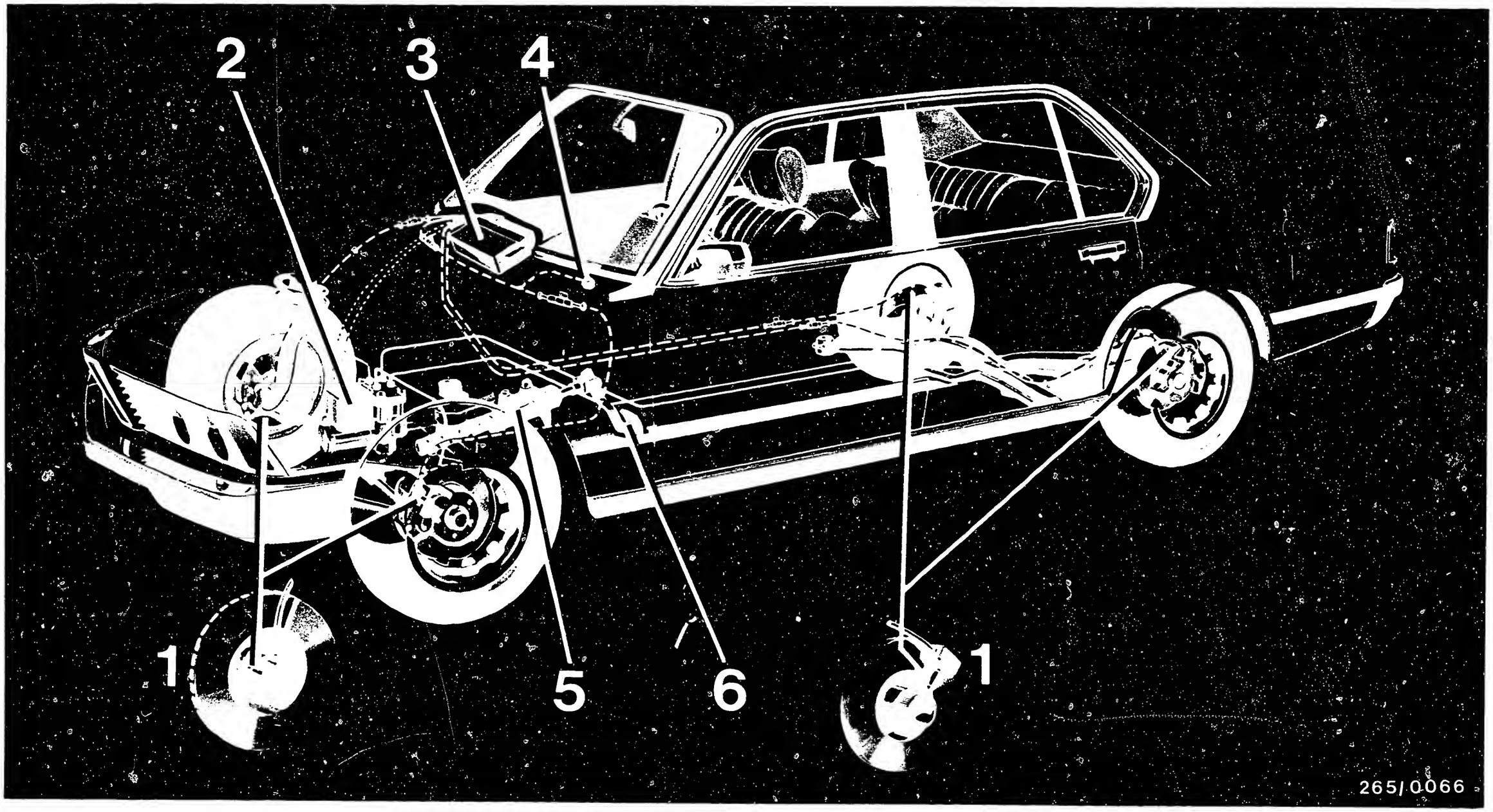
1 = Plug connector of wheel-speed sensor, rear left, pulled out of hole.
2 = Rubber sleeve

- Front-axle wheel-speed sensors:

One each on left and right in the steering knuckles. The plug connectors are in the engine compartment on left and right on the wheel housing in a frame at 90° to the spring struts.

- Rear-axle wheel-speed sensors:

One each on left and right near the brake calipers. Wheel-speed sensors must be mounted without washers. The plug connectors are under the vehicle in rubber sleeves which are let into the floor panel (picture). Carefully pull out rubber sleeves.



1 = 4 wheel-speed sensors on wheels
2 = Hydraulic modulator in engine compartment
3 = Controller in glove compartment (7 series) or in equipment space (6 series)
4 = Warning lamp in instrument panel
5 = Tandem brake master cylinder
6 = Brake pedal

.....Lines from controller to hydraulic modulator
- - - - Lines from wheel-speed sensors to controller
——— Dual-circuit diagonal brake system

Installation position of components - BMW 6 and 7 series models

Checking the brake system for leaks

	High-pressure test	Low-pressure test
Line test pressure gauge pressure	50 bar	2-5 bar
Test duration	40 seconds	5 minutes
Pressure drop of set value	8% (max)	0 (constant)

Note
The leakage check, which must be performed in both brake circuits, comprises high-pressure and low-pressure testing.

High-pressure test

- Connect pressure tester to fixed calliper. To do this, unscrew bleeder screw and screw in fitting. Then bleed pressure tester.

- Allow engine to run at medium speed and generate as high a vacuum as possible by suddenly releasing the accelerator pedal.

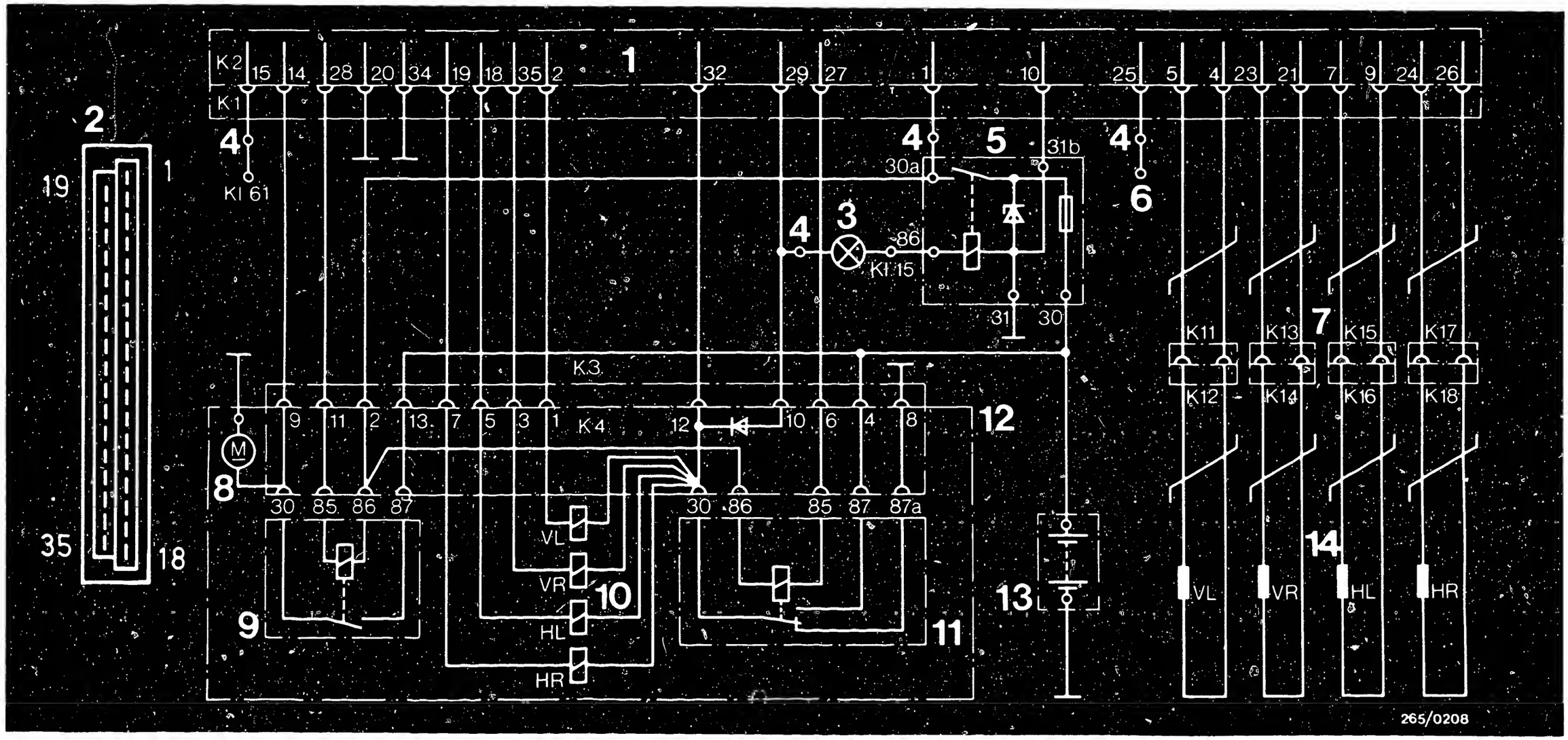
- Using the brake-pedal actuating device depress the brake pedal until a line pressure of 50 bar gauge pressure is generated. Then secure brake pedal in this position.

- During the test period of 40 seconds, the pressure drop may not be greater than 8% of the set value. If the pressure drop is greater than this figure, the leak (brake master cylinder, brake hoses, brake lines, brake callipers) must be sought and eliminated, or the hydraulic modulator must be replaced.

Low-pressure test

- Release brake pedal actuating device until a line pressure of 2 ... 5 bar gauge pressure is indicated on the pressure gauge.

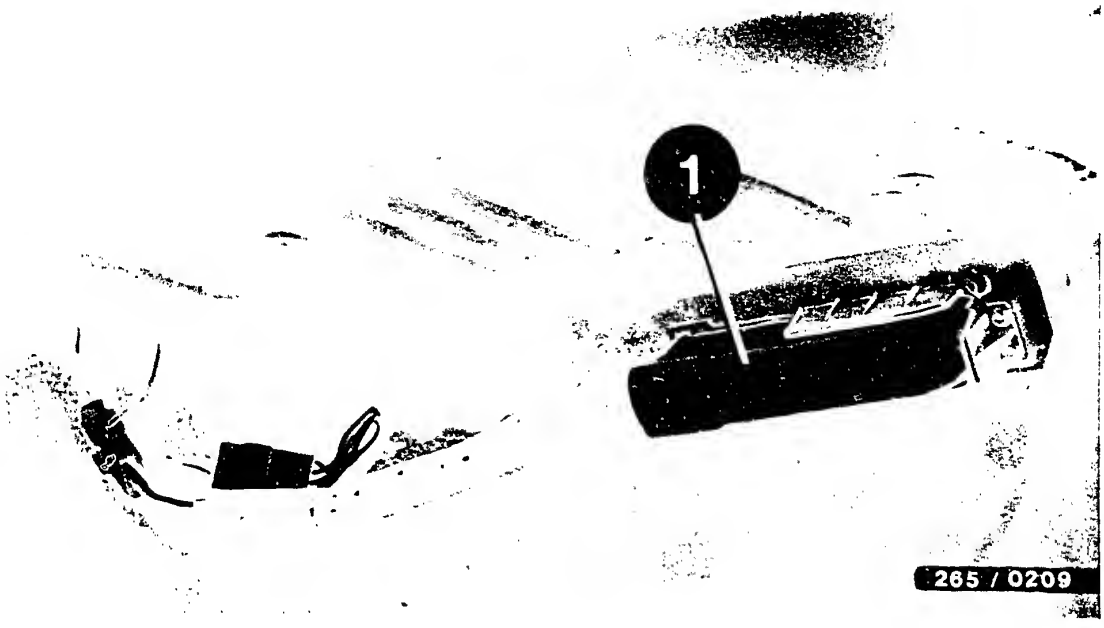
- During a test period of 5 minutes the set pressure may not drop. If a drop in pressure is detected, the leak must be sought and eliminated, and the brake master cylinder or the hydraulic modulator must be replaced.



1 = Controller
2 = Multiple plug (35-pin)
3 = ABS warning lamp
4 = 4-pin plug near control unit
5 = Overvoltage protection relay
6 = To stop-lamp switch (+)
7 = Cable connector
8 = Return-pump motor
9 = Motor relay
10 = Solenoid-op. valves
11 = Valve relay
12 = Hydraulic modulator
13 = Battery
14 = Wheel-speed sensor

VL = FL = front left
VR = FR = front right
HA = RA = rear axle
HL = RL = rear left
HR = RR = rear right
K1 to K18 = ABS plug connectors

ELECTRICAL TERMINAL DIAGRAM FOR LANCIA THEMA

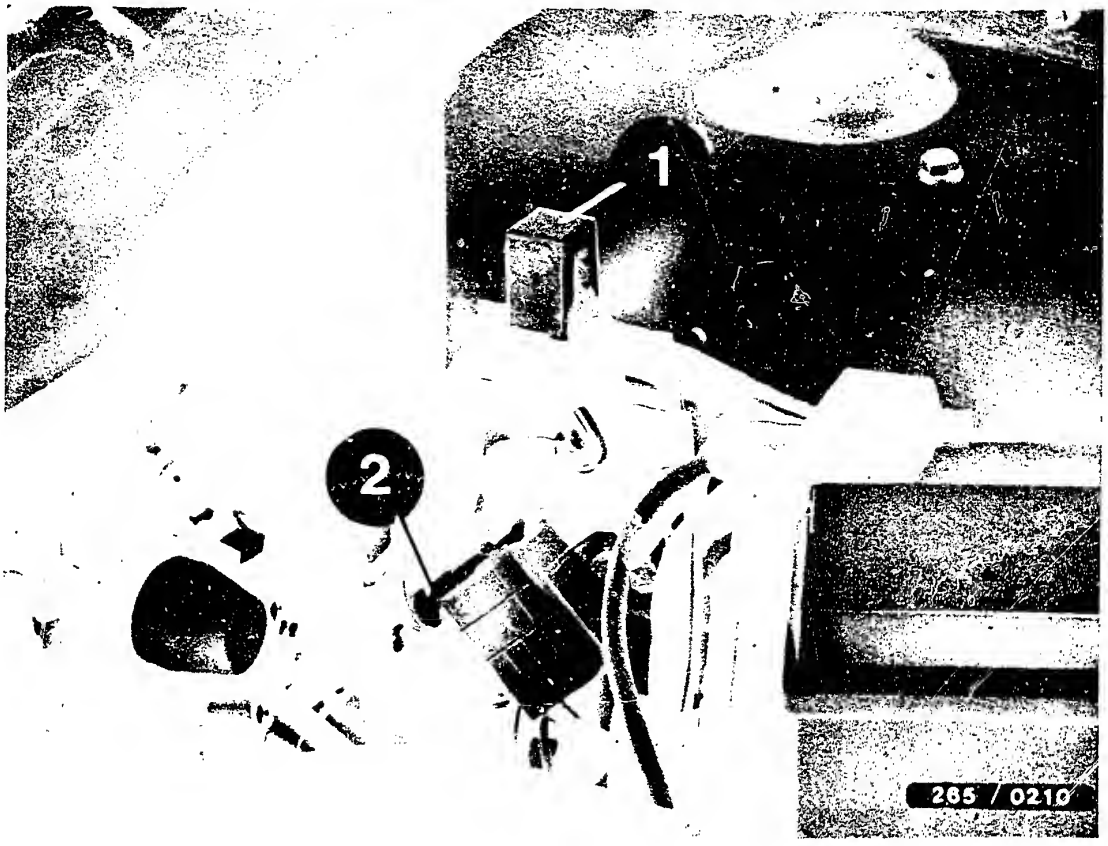


1 = ABS control unit

Installation position of components

The indications "right" and "left" apply always as viewed in the forward direction of travel.

- Control unit: Below glove shelf.
- Hydraulic modulator: In engine compartment, front left, in front of battery.
- Ground terminal: On battery B -
- ABS warning lamp: In instrument panel.



1 = Overvoltage protection relay
2 = Wheel-speed sensor plug connector

• Overvoltage protection relay:
In engine compartment on left, near spring strut.

• Front-axle wheel-speed sensors:
One each on left and right in steering knuckles.
Corresponding plug connectors:
In engine compartment on left, below overvoltage protection relay and on right on spring strut crown.

• Rear-axle wheel-speed sensors:
One each on left and right behind brake disks.
Corresponding plug connectors:
On left and right in luggage-compartment recesses.

TEST CHART AND REPAIR INSTRUCTIONS FOR
AUDI QUATTRO, BMW 3 SERIES MODELS, OPEL SENATOR / MONZA, PORSCHE 928

Test prerequisites for testing with ABS 2-LED tester

- Check ground connection of return pump and of over-voltage protection relay term. 31 for security and corrosion.
- Visually examine hydraulic connections and joints on hydraulic modulator for leaks.
- If the ABS warning lamp comes on occasionally while driving (e.g. after switching on loads) and goes out again by itself, check battery and power supply (alternator, regulator and voltage drops).
- If the ABS warning lamp is constantly lit and does not go out, check the following points:
  Multiple plug correctly seated on controller and latched?
  All plug contacts O.K.?
  Spring contacts engaged?
  Check proper installation position of seal ring in controller plug:
  curvature downwards.
  Check correct assignment of wheel-speed-sensor leads at controller plug.
  Front left wheel-speed sensor to term. 6 (BMW, Opel, Porsche) or term. 22 (Audi) and term. 4.
  Front right wheel-speed sensor to term. 23 Audi, Porsche or term. 11 (BMW, Opel, Porsche as of 9.85) and term. 21.
  Rear left wheel-speed sensor to term. 8 and term. 9.

- V-belt snapped?
  (No voltage supply from alternator, charge and ABS warning lamp lights up).

- To perform testing, switch on ignition in all program-selector switch settings (tester uses power supply from vehicle battery).

- Observe LED (green) for power supply in all program-selector switch settings.

- Connect ABS 2-LED tester to ABS wiring harness.

I M P O R T A N T !

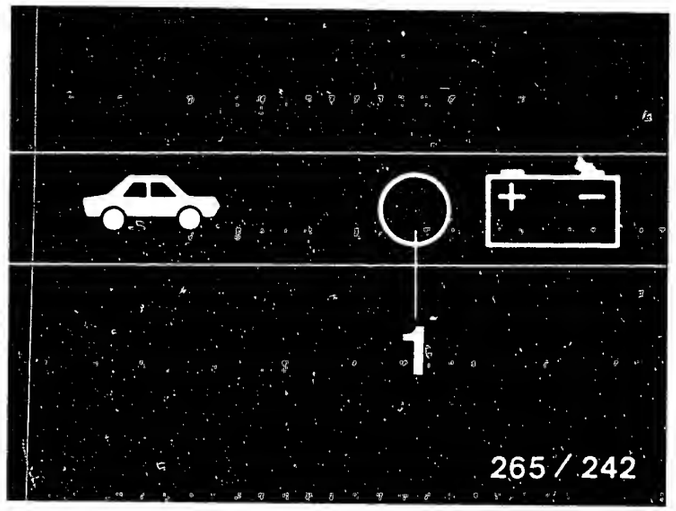
Only detach and attach controller with ignition switched off.
Never drive with tester connected!
The entire test program is to be repeated whenever repairs have been performed.
The antilock braking system is a vehicle safety system. Performing work on this system requires detailed system knowledge.
The conventional brake system must be in proper working order.

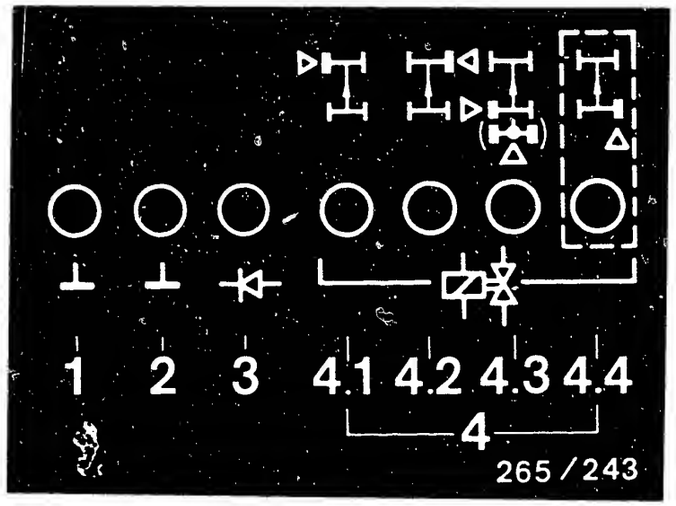
General information on trouble-shooting:

Test all leads for short-circuit to ground and contact with positive leads as well as for worn insulation and crushing.

Test chart for Audi Quattro, BMW 3 series, Opel Monza/Senator, Porsche 928

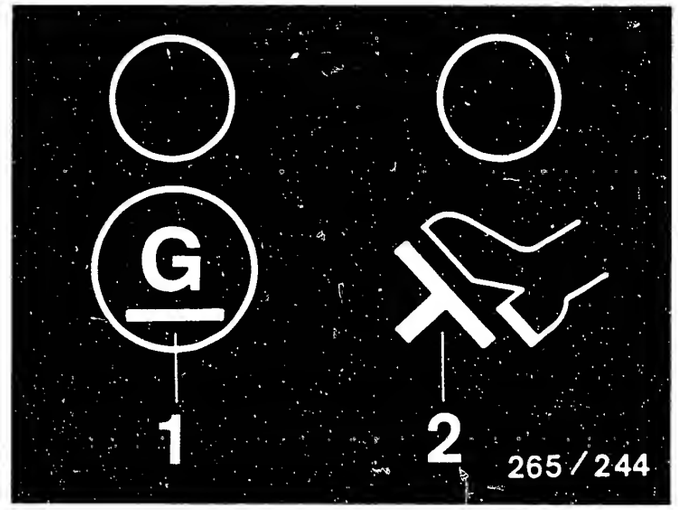
Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (reading)	Possible cause of trouble
all	Power supply (term. 20 and term. 1) for all test steps	Ignition on	LED (1) for battery voltage constantly lit (top diagram)	• Battery insufficiently charged • High voltage drops • Fuse defective • Overvoltage-protection relay defective • Check lead to ignition lock term. 15
1	Ground connections (term. 34, term. 10) Diode for warning lamp (term. 29, term. 32); solenoid-operated valve internal resistances (term. 2, term. 35, term. 18); off-position and ground connection of valve relay. ABS warning lamp.	Ignition on	6 LEDs (1, 2, 3, 4.1, 4.2, 4.3) lit with equal intensity (bottom diagram) ABS warning lamp in vehicle must light up.	• LEDs (1, 2) for ground connections not lit: Open circuit at ground terminals • LED (3) for warning lamp not lit: ABS warning lamp defective, diode defective • LED (4.1, 4.2 or 4.3) for solenoid-operated valve not lit: Check corresponding plug-in connection for solenoid-operated valve and leads. Internal resistance of solenoid-operated valve 0.7 ... 1.7 Ω. • All LEDs (4) for solenoid-op. valves and LED (3) for warning lamp not lit: Check valve relay ground connection, valve relay defective. • LEDs lit dimly: Contact resistance in corresponding circuit. • ABS warning lamp does not light up: warning lamp defective. Note: the other 6 LEDs light up.

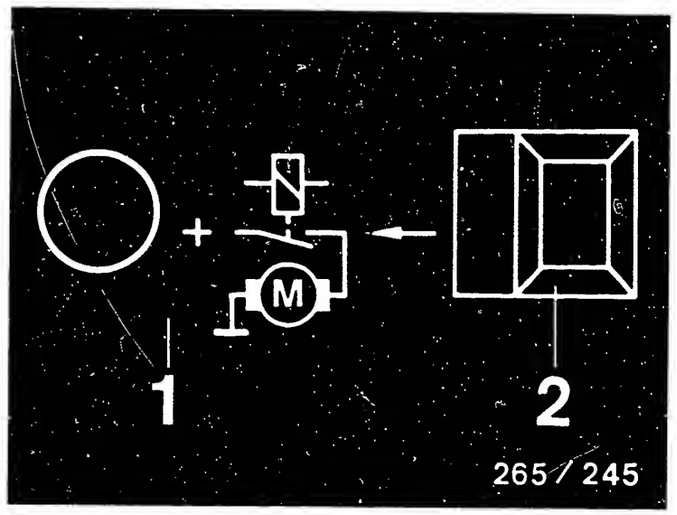




Test chart for Audi Quattro, BMW 3 series, OPEL Monza/Senator, Porsche 928

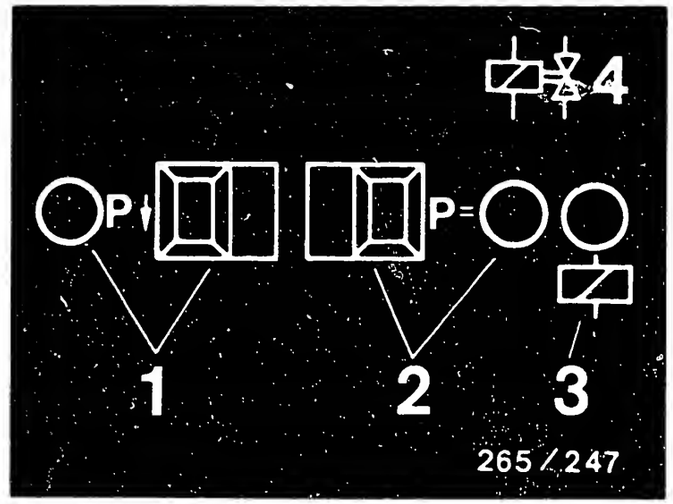
Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (reading)	Possible cause of trouble
2	Alternator voltage from term. 61 (term. 15)	Ignition on	LED (1) for alternator lit (top diagram)	• In some cases, LED (1) only goes out after burst of throttle (test is then O.K.) • Check lead to alternator term. 61 • Alternator defective
		Start engine	LED (1) goes out when engine running	
	Stop-lamp switch (term. 25).	Ignition on	LED (2) for stop-lamp switch lit	• Check lead to stop-lamp switch • Stop-lamp switch defective • Lead incorrectly connected to stop-lamp switch.
		Press brake pedal	LED (2) goes out	
3	Motor relay, pump motor in hydraulic modulator (term. 28)	Ignition on Press key (2) continuously	LED (1) lit, pump motor operating (bottom diagram)	Note: • Motor relay defective. • Check ground connection of hydraulic modulator • Pump motor defective.





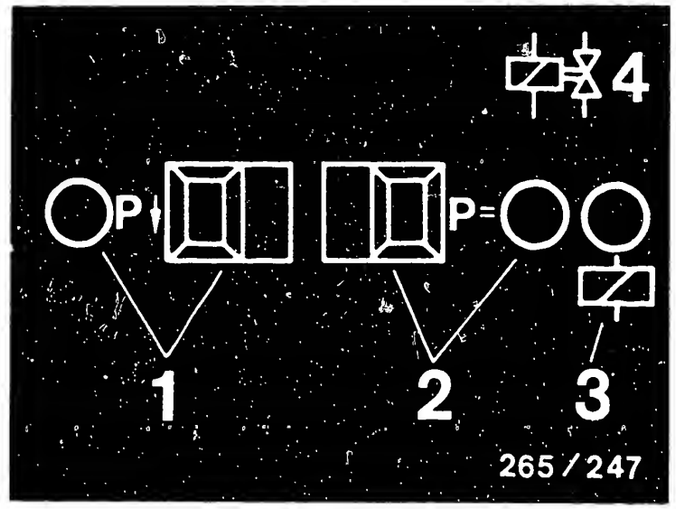
Test chart for Audi Quattro, BMW 3 series, Opel Monza/Senator, Porsche 928

Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (reading)	Possible cause of trouble
4	Longitudinal acceleration sensor a_l (term.16) and transverse acceleration sensor a_Q (term.13)	Ignition on	not applicable	-----
5	Valve relay - operation (term. 27)	Ignition on	LED (3) for valve relay lit (top diagram)	• Test valve relay and leads to term. 85 and term. 86.
	Functional test and identity check of solenoid-operated valves in hydraulic modulator. Note: Perform test separately for each wheel one after the other. Testing on rear axle may be performed on left-hand or right-hand wheel.	Raise vehicle. Ignition on. The wheel under test must be freely rotatable by hand. Set wheel-selection switch to wheel under test (Items 2, 3, and 4) (bottom diagram). Keep to sequence of operations.		



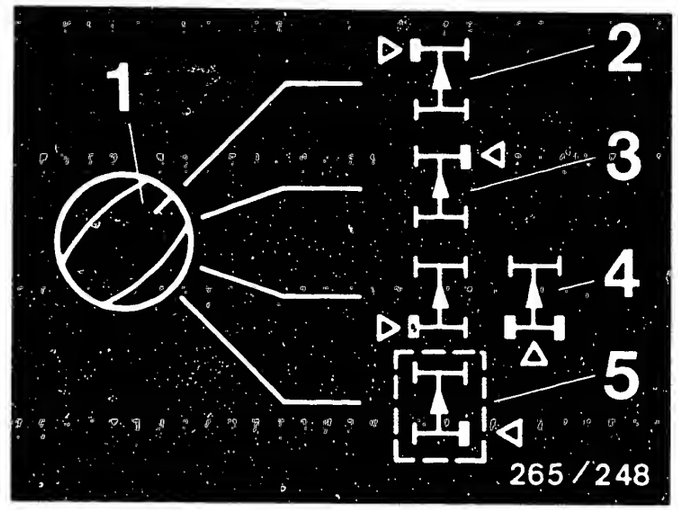
Test chart for Audi Quattro, BMW 3 series, Opel Monza/Senator, Porsche 928

Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (reading)	Possible cause of trouble
5 (continued)	Pressure holding function	1. Press key P = (2) continuously	LED P = (2) lit (top diagram)	• Battery voltage too low: repeat test with engine running. • Valve relay defective, open-circuit in lead from valve relay, term. 87 to B+, • brake lines mixed up at hydraulic modulator, • current value is not obtained (LED for pressure hold or pressure reduction goes out) because the battery is inadequately charged: repeat test with engine running. • Hydraulic modulator defective.
		2. Press brake pedal continuously	Wheel under test rotatable by hand	
		3. Release key P=(2)	LED P= (2) goes out, wheel locks	
	Pressure reduction function	4. Press key P (1) for pressure reduction	LED (1) for pressure reduction lit, wheel rotatable by hand	
		5. Release key P (1) for pressure reduction	LED (1) for pressure reduction goes out, wheel locks	
		6. Release brake pedal		

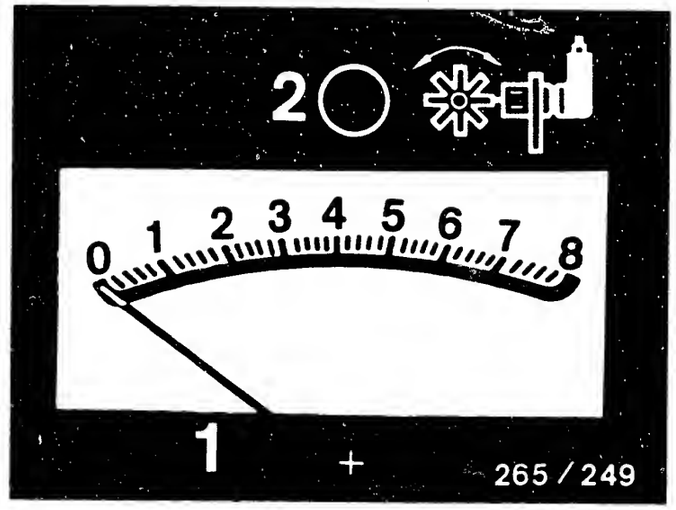


Test chart for Audi Quattro, BMW 3 series, Opel Senator/Monza, Porsche 928

Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (Reading)	Possible cause of trouble
6	Functional test and identity check of wheel-speed sensors. Note: Perform test separately for each wheel one after the other. Front left wheel: Audi Quattro: term. 4 and term. 22. BMW 3 series, Porsche 928, Opel Senator/Monza: term. 4 and term. 6. Front right wheel: Audi Quattro, Porsche 928 up to 1985: term. 21 and term.23. Porsche 928 as of 86: term. 21 and term.11 BMW 3 series, Opel Senator/Monza: term. 11 and term. 21. Rear left wheel: Audi Quattro, Porsche 928: term. 7 and term. 9. BMW 3 series, Opel Senator/Monza: term. 8 and term. 9. Rear right wheel: Audi Quattro, BMW 3 series, Porsche 928, Opel Senator/Monza: term. 24 and term.26	Raise vehicle. Ignition on. The wheel under test must be freely rotatable by hand. Set wheel-selection switch (top diagram) to the wheel under test. (Items 2, 3, 4, 5 in top diagram). Turn wheel by hand until LED (No. 2, bottom diagram) above the instrument lights up without flickering (at approx. 1 revolution per sec). Make reading on instrument.	Lowest reading Audi Quattro, Porsche 928 up to approx. 7.85: greater than 1.0 scale graduations BMW 3 series, Opel Senator/Monza, Porsche 928 as of 1986: greater than 1.6 scale graduations Allowable width of variation: max. 25% of highest reading	• Wheel-speed sensor lead mixed up • Open circuit in wheel speed sensor lead • Wheel-speed sensor defective, winding resistance: Porsche 928, Audi Quattro: 0.8 ... 1.8 kΩ BMW 3 series, Opel Senator/Monza: 0.6 ... 1.6 kΩ • Air gap between wheel-speed sensor and ring gear too great • Ring gear defective or loose • Ring gear with incorrect number of teeth installed. Audi Quattro: 96 teeth. BMW 3 series, Opel Senator/Monza: 48 teeth. Porsche 928: 90 teeth. As of 1986: 45 teeth. • Wheel-bearing play too great



Finally, perform a road test. With engine running, warning lamp must go out. Drive at at least 30 km/h. Warning lamp must not come on again.



Repair instructions for wheel-speed sensors

Removing the wheel-speed sensors on the front axle

- Switch off ignition.
- Plug connector in engine compartment or, on Opel, on the respective frame side members.
- Take apart plug connector.
- Loosen fastening screw for wheel-speed sensor and carefully take out wheel-speed sensor. Do not use force.

Porsche:

- Take off front wheel. Remove intake hose to air filter and shielding plate of front exhaust system.
- After loosening, pull out wheel-speed sensor with rubber sleeve and brake line.

Installing the wheel-speed sensors on the front axle (general)

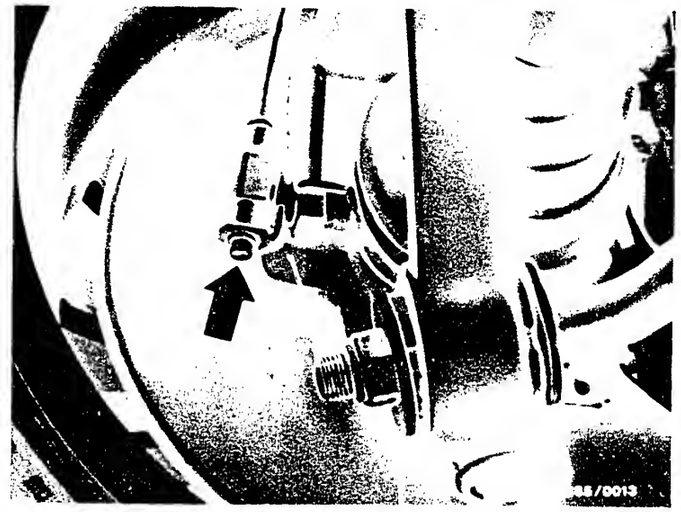
- Check O-ring for cracks and replace if necessary.
- Take new wheel-speed sensor out of protective sleeve only when ready to install.

Audi:

- Replace plastic tip on wheel-speed sensor edge. Ensure correct seating.

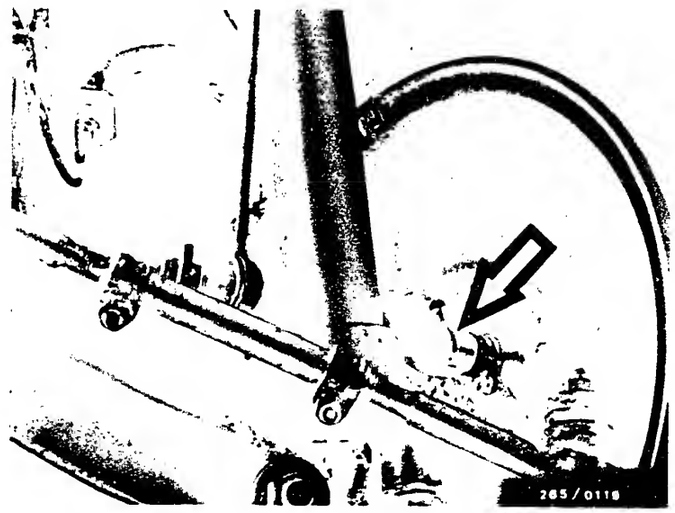
General:

- Grease wheel-speed sensor housing with Molykote Longterm 2.
- Before installing the wheel-speed sensors, make sure that there are no metallic foreign bodies on the permanently magnetic edges.



Audi:
Arrow = Fastening screw for wheel-speed sensor

Opel:
Arrow = Wheel-speed sensor



Installing the wheel-speed sensors on the front axle (continued)

- Carefully press wheel-speed sensor into mounting hole until it comes up against the ring gear.
  On Audi, air gap is correctly set by plastic tip. Do not knock.
  Do not damage O-ring.

- Secure wheel-speed sensors with new micro-encapsulated screws. Tighten fastening screws to 6 ... 8 Nm.
  Exception: Opel and Porsche as of 86 model year: greater than 8 Nm.

- Re-attach wheel-speed sensor lead at the points provided.

Porsche:

- Mount exhaust-system cover, intake hose and front wheel.

Audi:

- Observe routing of lead over ignition coil.
  Lead must not hang down.

Opel:
Arrow = Wheel-speed sensor plug connector

BMW:
Arrow = Front left wheel-speed sensor. Make sure that the front-axle wheel-speed sensors are not mixed up when installing. Air gap will be too great and signal too small.

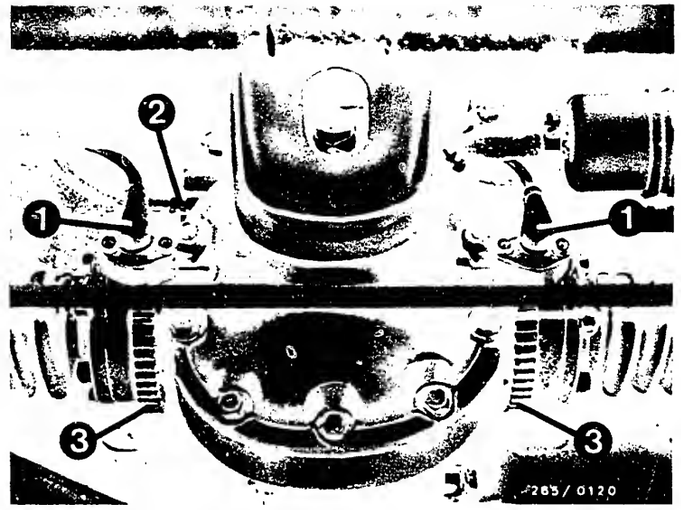
Repair instructions for wheel-speed sensors (continued)

Removing the wheel-speed sensors on the rear axle:

- Switch off ignition.
- Take apart wheel-speed sensor plug connector.
- Release wheel-speed sensor lead from fastening points.
- Loosen fastening screw and pull out wheel-speed sensor.
  Do not use force.
- On Opel, do not unscrew holding bracket. Do not lose shims.

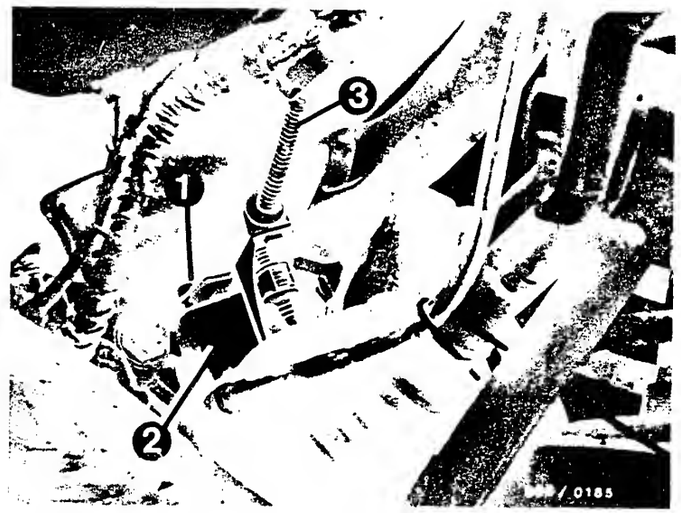
Installing the wheel-speed sensors on the rear axle

- Check O-ring for cracks and replace if necessary.
- Take new wheel-speed sensor out of protective sleeve only when ready to install.
- On Audi, replace plastic tip on wheel-speed sensor edge. Ensure correct seating.
- Grease wheel-speed sensor housing with Molykote Longterm 2.
- On Opel, mount shims.
- Make sure that there are no metallic foreign bodies on the permanently magnetic edge.
- Carefully press wheel-speed sensor into mounting hole as far as it will go. Do not knock.
- Air gap is correctly set by plastic tip on Audi.
- On Opel, measure air gap between wheel-speed sensor edge and ring gear with feeler gauge.
  Specification: 0.3 ... 1.0 mm.
  If necessary, correct air gap with shims.



Opel:
1 = Wheel-speed sensor
2 = Wheel-speed sensor plug connector
3 = Ring gear

Porsche:
1 = Wheel-speed sensor
2 = Wheel carrier
3 = Wheel-speed sensor lead



Installing the wheel-speed sensors on the rear axle (continued)

- Use new micro-encapsulated fastening screw.

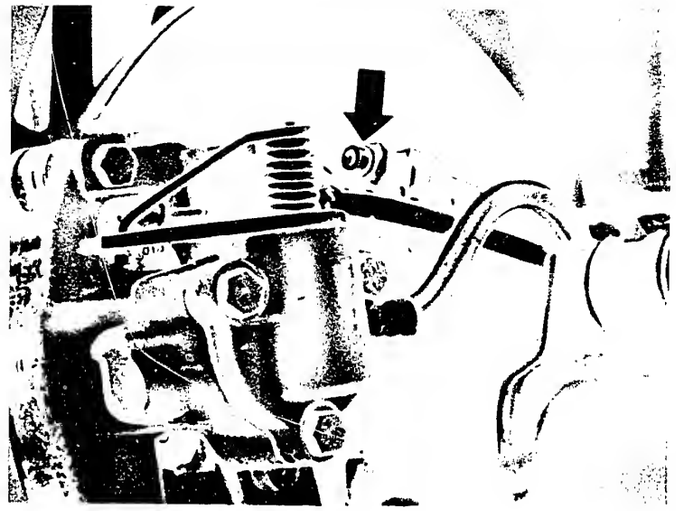
  Tighten fastening screw to 6 ... 8 Nm.

  Exception: Opel and Porsche as of 86 model year: greater than 8 Nm

  When tightening, press wheel-speed sensor into hole by hand.

  This prevents the wheel-speed sensor lifting off the ring gear and the air gap becoming too great.

- Re-attach wheel-speed sensor leads at the points provided.



Audi:
Arrow = Fastening screw for wheel-speed sensor

Porsche:
Arrow = Wheel-speed sensor plug connector

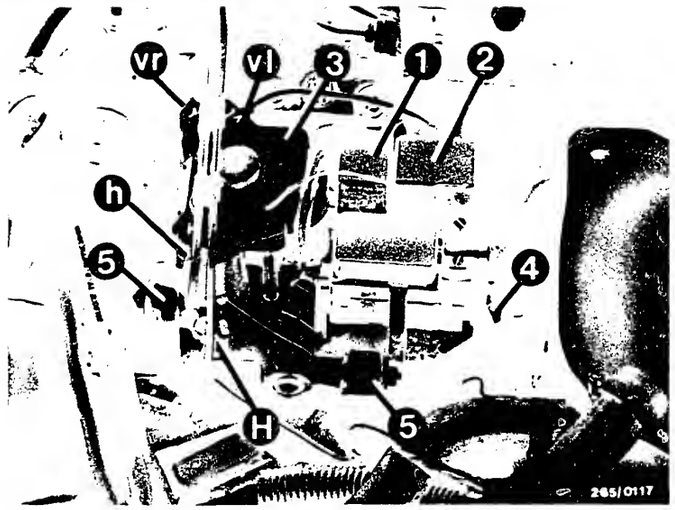
Repair instructions for hydraulic modulators

Removing the hydraulic modulator

- For safety reasons, the hydraulic modulator must not be repaired, but the complete unit must be replaced.
  Exceptions to this are the return-pump relay and the valve relay. Both relays may be replaced.

- Apart from the brake-line connections, it is not permissible to loosen any screws on the hydraulic modulator. In particular the hexagon-socket-head cap screws (bottom picture - arrows) may under no circumstances be loosened. After loosening, it is no longer possible to get the brake circuits leak-tight.
  Danger!

- Check the hydraulic modulator and brake-line connections for leaks by means of a visual examination. If brake fluid is escaping, tighten the brake-line connections (12...16 Nm) or replace, or replace the hydraulic modulator.
  Pay particular attention to the joints identified by arrows.



Audi:
1 = Valve relay
2 = Motor relay
3 = Hydraulic modulator
4 = Pump motor ground terminal
5 = Fastening screws

Arrows = Joints

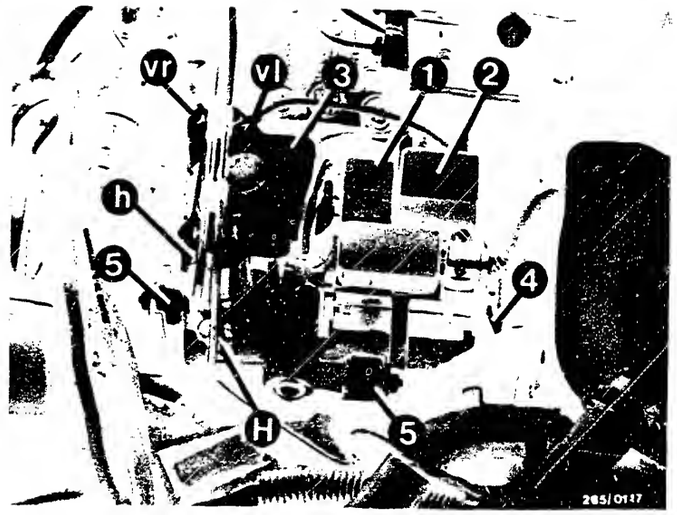
On the base of the hydraulic modulator there is a vent hole to the pump pistons.
A slight escape of brake fluid is possible at this point.

A complaint is only justified if, after pressing the brake pedal several times, a pool of brake fluid is formed under the hydraulic modulator.

- When removing and installing the brake lines, make sure that the lines are marked in accordance with the markings on the hydraulic modulator and that they are not mixed up when re-connecting (e.g. FL of hydraulic modulator must be connected to the front left wheel brake cylinder).

- Markings on hydraulic modulator

Opel	BMW Porsche Audi		
vl	l	=	Connection for brake line, front left (wheel-brake cylinder)
vr	r	=	Connection for brake line, front right (wheel-brake cylinder)
h	h	=	Connection for brake line of rear axle
V	V	=	Front-axle brake circuit from brake master cylinder
H	H	=	Rear-axle brake circuit from brake master cylinder



Audi:

1 = Valve relay
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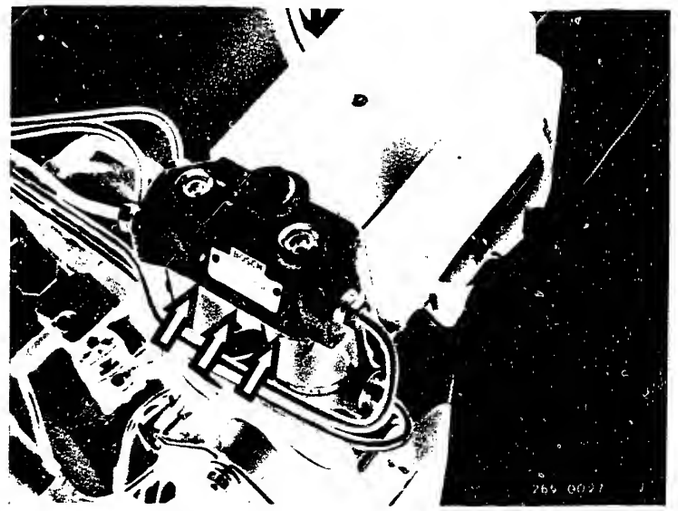
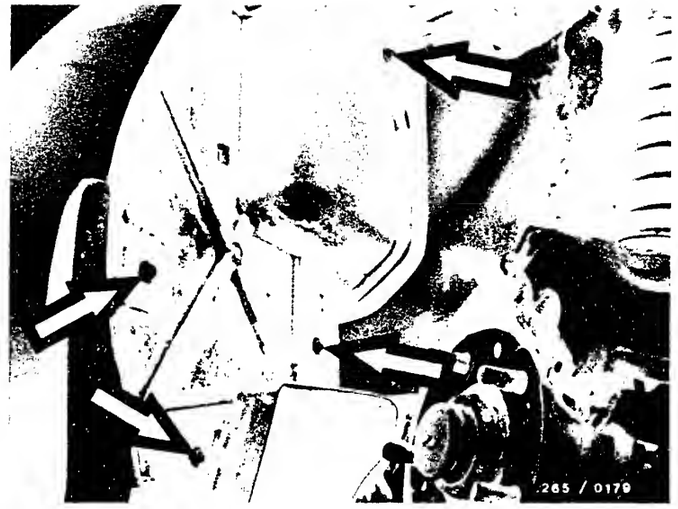


Repair instructions for hydraulic modulators (continued)

- Use only the specified double-end flare nut wrench 9x11 mm for loosening and tightening the brake lines.
- Mark brake lines and remove from hydraulic modulator.
- Catch the brake fluid and do not bring it into contact with your skin or clothing or with paintwork.
- Immediately seal the brake lines and connections with dummy plugs.
- Disconnect ground cable from pump motor.
- Loosen fastening screw and remove cover.
- Loosen bracket and remove plug.
- Loosen hexagon nuts from holder and remove hydraulic modulator.

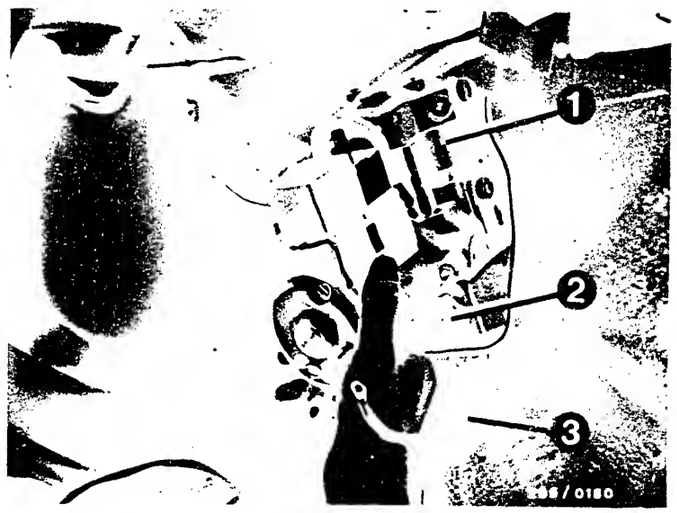


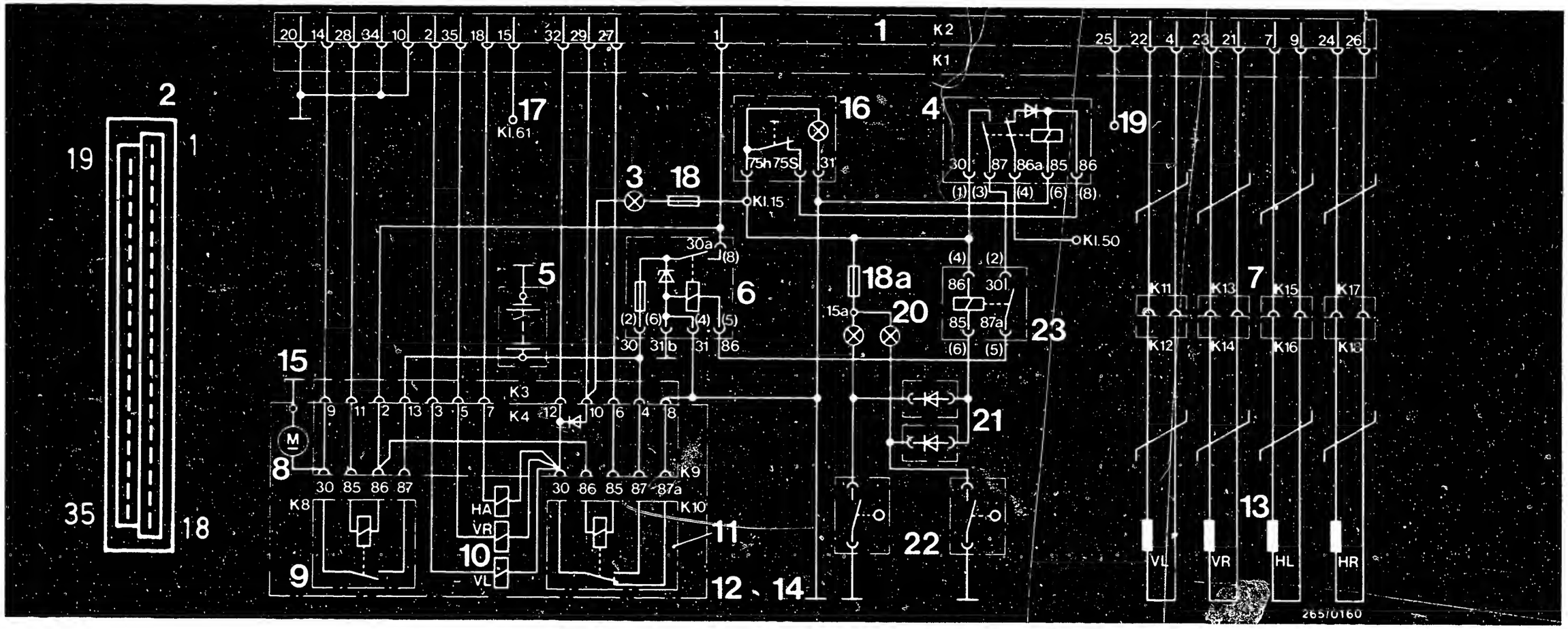
Porsche:
Arrows = Fastening screws for the wheel-house cover

Installation

- Mount hydraulic modulator in the holder and fasten with the hexagon nuts.
- Connect ground cable to pump motor. Plug on 13-pin plug and fasten with the bracket (4,5).
- Fasten cover on the hydraulic modulator with the screw.
- Connect the brake lines to the hydraulic modulator in accordance with the markings.
- Observe the tightening torque for the brake-line connections on the hydraulic modulator: 12...16 Nm.
- Bleed the brake system and check for leaks.
- Fully test the ABS with the tester.
- Completely check ABS with tester.

Porsche:
1 = Hydraulic modulator
2 = Fastening point on holder
3 = Ground line from pump motor

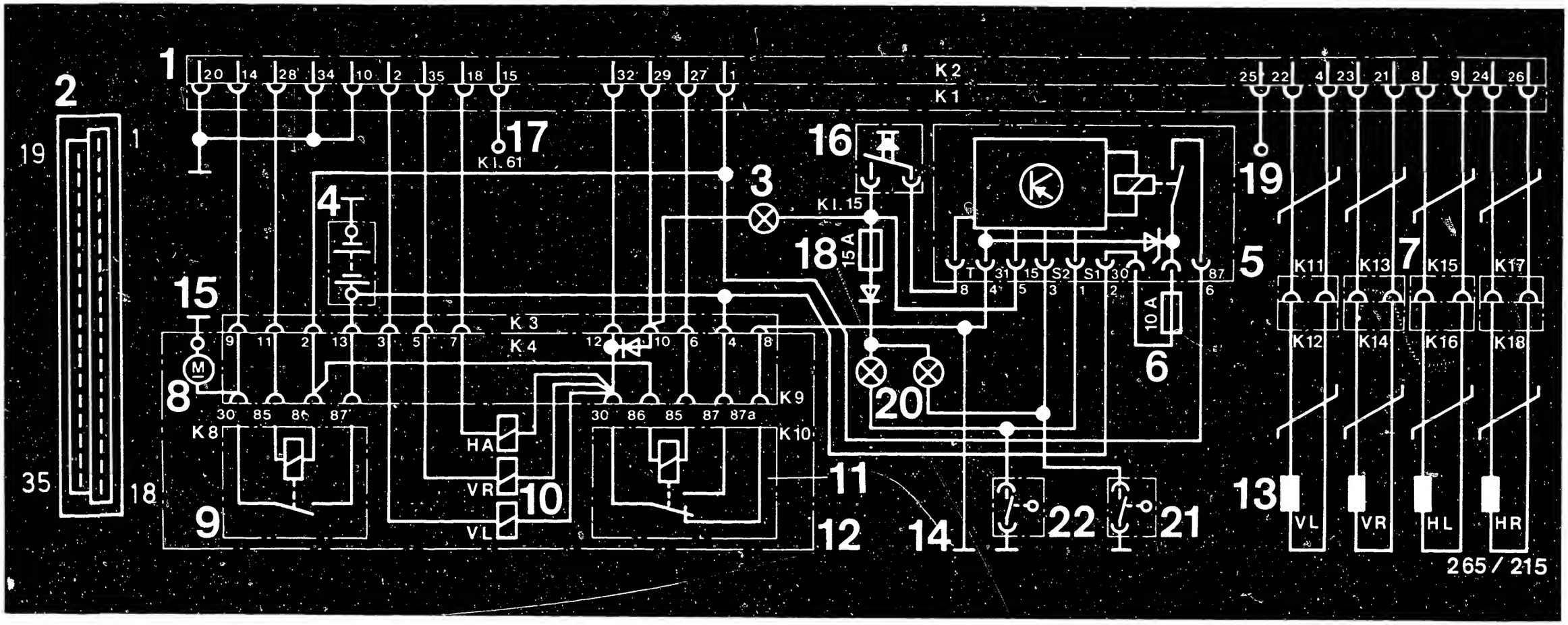




1 = Controller
2 = Multiple plug (35-pin)
3 = ABS warning lamp
4 = Relay for controller (step-by-step relay)
5 = Battery
6 = Overvoltage-protection relay
7 = Cable connector
8 = Return-pump motor
9 = Motor relay
10 = Solenoid-operated valves
11 = Valve relay
12 = Hydraulic modulator
13 = Wheel-speed sensor
14 = Ground terminal behind instrument panel
15 = Ground terminal, in engine compartment on left
16 = ABS switch
17 = to alternator
18 = Fuse in relay board with fuse holder
18a = Fuse No. 12 (15 A) in central-electrics box
19 = to stop-lamp switch
20 = Indicator lamps for differential locks
21 = Diode plug
22 = Switch for differential locks
23 = ABS switch-off relay

VL = Front left
VR = Front right
HL = Rear left
HR = Rear right
HA = Rear axle
K1,K2,etc. = Plug numbers

ELECTRICAL TERMINAL DIAGRAM FOR AUDI QUATTRO AND AUDI 80 QUATTRO (11.83→7.84)



1 = Controller
2 = Multiple plug (35-pin)
3 = ABS warning lamp
4 = Battery
5 = Combined relay
6 = Fuse (10 A) in combined relay
7 = Cable connector
8 = Return-pump motor
9 = Motor relay
10 = Solenoid-operated valves
11 = Valve relay
12 = Hydraulic modulator
13 = Wheel-speed sensor
14 = Ground terminal behing instrument panel
15 = Ground terminal, in engine compartment, on left
16 = ABS switch
17 = to alternator
18 = Fuse No. 12 (15 A) in central-electrics box
19 = to stop-lamp switch
20 = Indicator lamps for differential locks
21 = Switch for differential lock (rear)
22 = Switch for differential lock (center)

VL = Front left
VR = Front right
HL = Rear left
HR = Rear right
HA = Rear axle
K1, K2 etc. = Plug numbers

Electrical terminal diagram for all Audi Quattro vehicles as of 8.84 → 8.86

Installation position of components

The indications "right" and "left" apply always as viewed in the forward direction of travel.

- ABS warning lamp:

  In instrument panel.

- ABS switch:

  In instrument panel

- Front-axle wheel-speed sensors:

  One each on left and right in the steering knuckles.

- Rear-axle wheel-speed sensors:

  One each on left and right near brake calipers.

- Hydraulic modulator:

  In engine compartment on left in front of brake master cylinder.

- Ground terminal for ABS:

  On hydraulic modulator mounting.

- Controller:

  Audi 80 Quattro, Audi Quattro up to 7.84:
  In luggage compartment, rear, right, behind a cover.

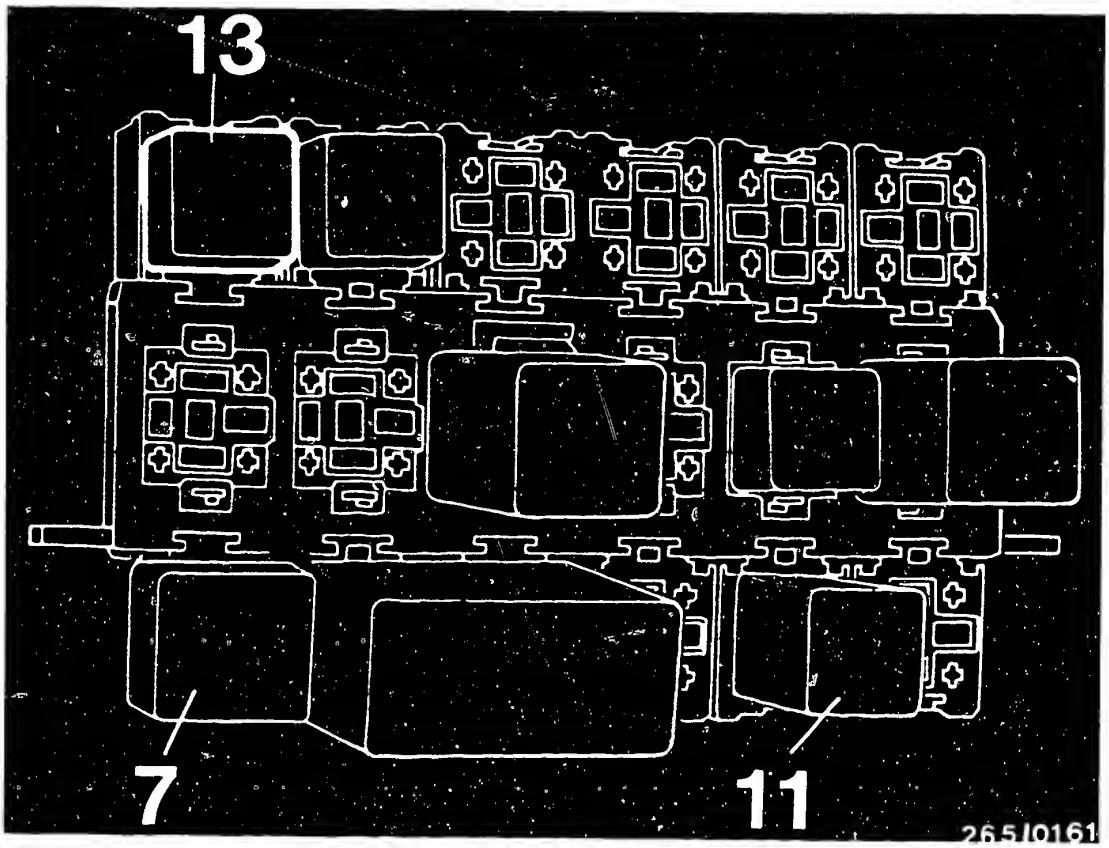
  All Quattro vehicles as of 8.84:
  Under rear seat bench on left.

- Switches for differential locks:

  One each in housings for center and rear-axle differential locks.

- Diode plug:

  Under instrument panel, near relay carrier.



- Relay for controller (step-by-step relay):

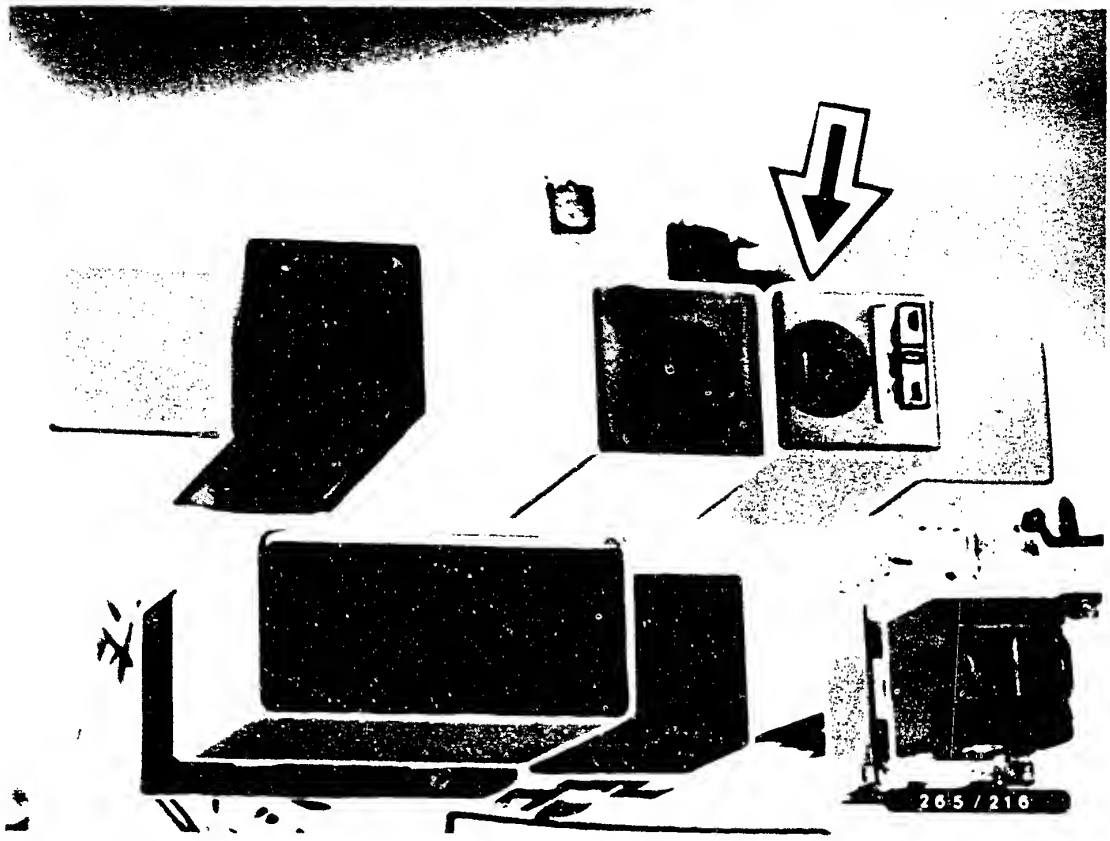
  Under the instrument panel on left-hand side in relay carrier, relay location 7

- Overvoltage protection relay:

  Under the instrument panel on left-hand side in relay carrier, relay location 11

- ABS switch-off relay for differential lock:

  Under the instrument panel on left-hand side in relay carrier, relay location 13.



- Combined relay as of 8.84:

  Under the instrument panel on right-hand side in relay carrier (see picture, arrow).

Checking the brake system for leaks

	High-pressure test	Low-pressure test
Line test pressure Gauge pressure	50 bar	6 bar
Test duration	45 seconds	3 minutes
Pressure drop of set value	4 bar (max.)	1 bar (max.)

Note
The leakage check, which must be performed in both brake circuits, comprises high-pressure and low-pressure testing.

High-pressure test

- Connect pressure tester to fixed calliper. To do this, unscrew bleeder screw and screw in fitting. Then bleed pressure tester.

- Allow engine to run at medium speed and generate as high a vacuum as possible by suddenly releasing the accelerator pedal.

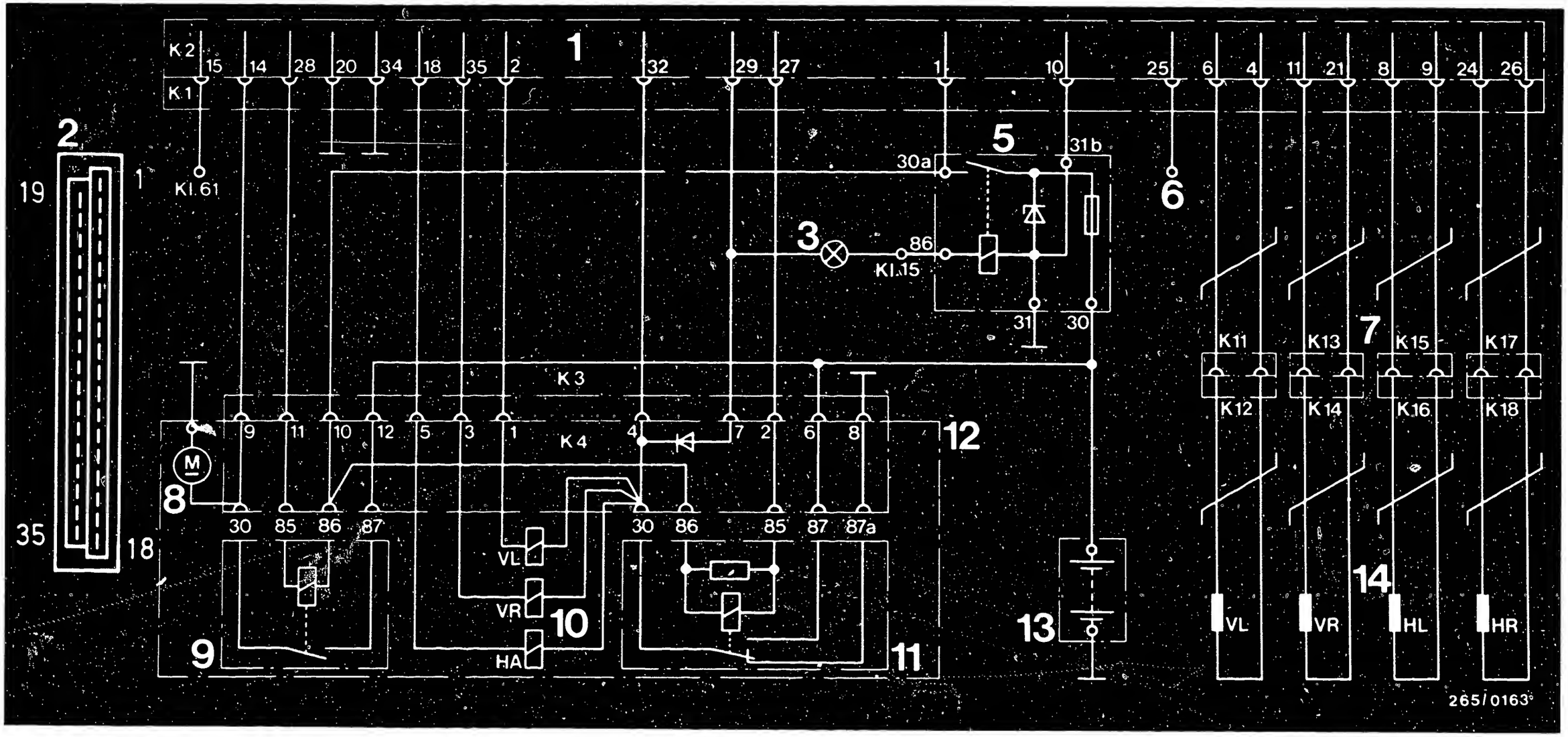
- Using the brake-pedal actuating device depress the brake pedal until a line pressure of 50 bar gauge pressure is generated. Then secure brake pedal in this position.

- During the test period of 45 seconds, the pressure drop may not be greater than 4 bar of the set value. If the pressure drop is greater than this figure, the leak (brake master cylinder, brake hoses, brake lines, brake callipers) must be sought and eliminated, or the hydraulic modulator must be replaced.

Low-pressure test

- Release brake pedal actuating device until a line pressure of 6 bar gauge pressure is indicated on the pressure gauge.

- During a test period of 3 minutes the set pressure may not drop. If a drop in pressure is detected, the leak must be sought and eliminated, and the brake master cylinder or the hydraulic modulator must be replaced.



1 = Controller
2 = Multiple plug (35-pin)
3 = ABS warning lamp
5 = Overvoltage protection relay
6 = to stop-lamp switch (+)
7 = Cable connector
8 = Return-pump motor
9 = Motor relay
10 = Solenoid-operated valves
11 = Valve relay
12 = Hydraulic modulator
13 = Battery
14 = Wheel-speed sensor

VL = Front left
VR = Front right
HA = Rear axle
HL = Rear left
HR = Rear right
K1 to K18 = ABS plug connectors

ELECTRICAL TERMINAL DIAGRAM FOR BMW 320i, 323i as of 9.83 → 8.87

Installation position of components

The indications "right" and "left" always apply as viewed in the forward direction of travel.

1 =	Controller:	To left of steering column behind the cover.
2 =	Ground terminal for ABS:	To right of controller.
3 =	Overvoltage protection relay:	To right of controller.
4 =	Stop-lamp switch:	On brake pedal.
•	ABS warning lamp:	In instrument panel.

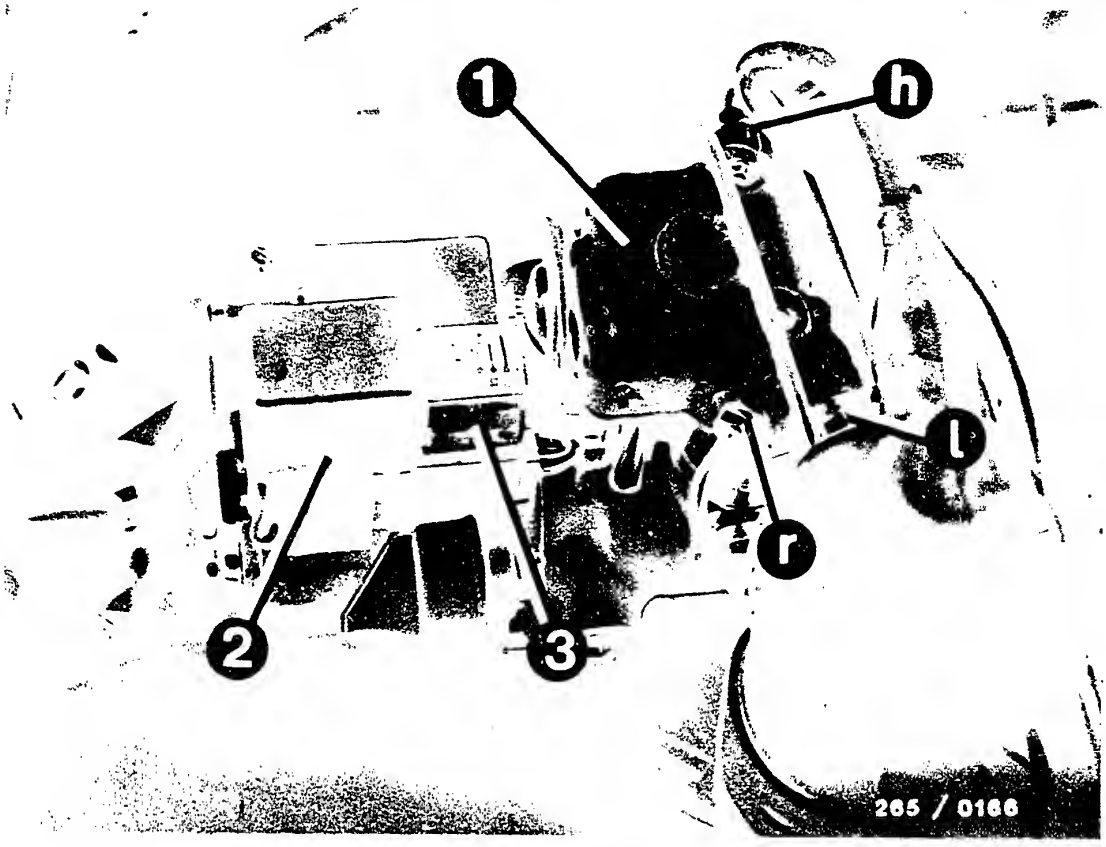
Arrow = Front left wheel-speed sensor.
Make sure that the wheel-speed sensors of the front wheels are not mixed up when installing. Air gap will be too great and signal too small.

- Front-axle wheel-speed sensors:

One each on left and right in the steering knuckles.

- Rear-axle wheel-speed sensors:

One each on left and right near the brake calipers.



1 = Hydraulic modulator:
In engine compartment, behind left-hand headlamp.

l = Brake line to wheel-brake cylinder, front left
r = Brake line to wheel-brake cylinder, front right
h = Brake line to wheel-brake cylinders of rear wheels

2 = Motor relay
3 = Valve relay

The hydraulic modulator must not be repaired, but may be replaced as a complete unit only.

Exception: Change of relay.

Checking the brake system for leaks

	High-pressure test	Low-pressure test
Line test pressure Gauge pressure	50 bar	2 ... 5 bar
Test duration	2 minutes	5 minutes
Pressure drop of set value	8 % (max.)	0 (constant)

Note
The leakage check, which must be performed in both brake circuits, comprises high-pressure and low-pressure testing.

High-pressure test

- Connect pressure tester to fixed caliper. To do this, unscrew bleeder screw and screw in fitting. Then bleed pressure tester.

- Allow engine to run at medium speed and generate as high a vacuum as possible by suddenly releasing the accelerator pedal.

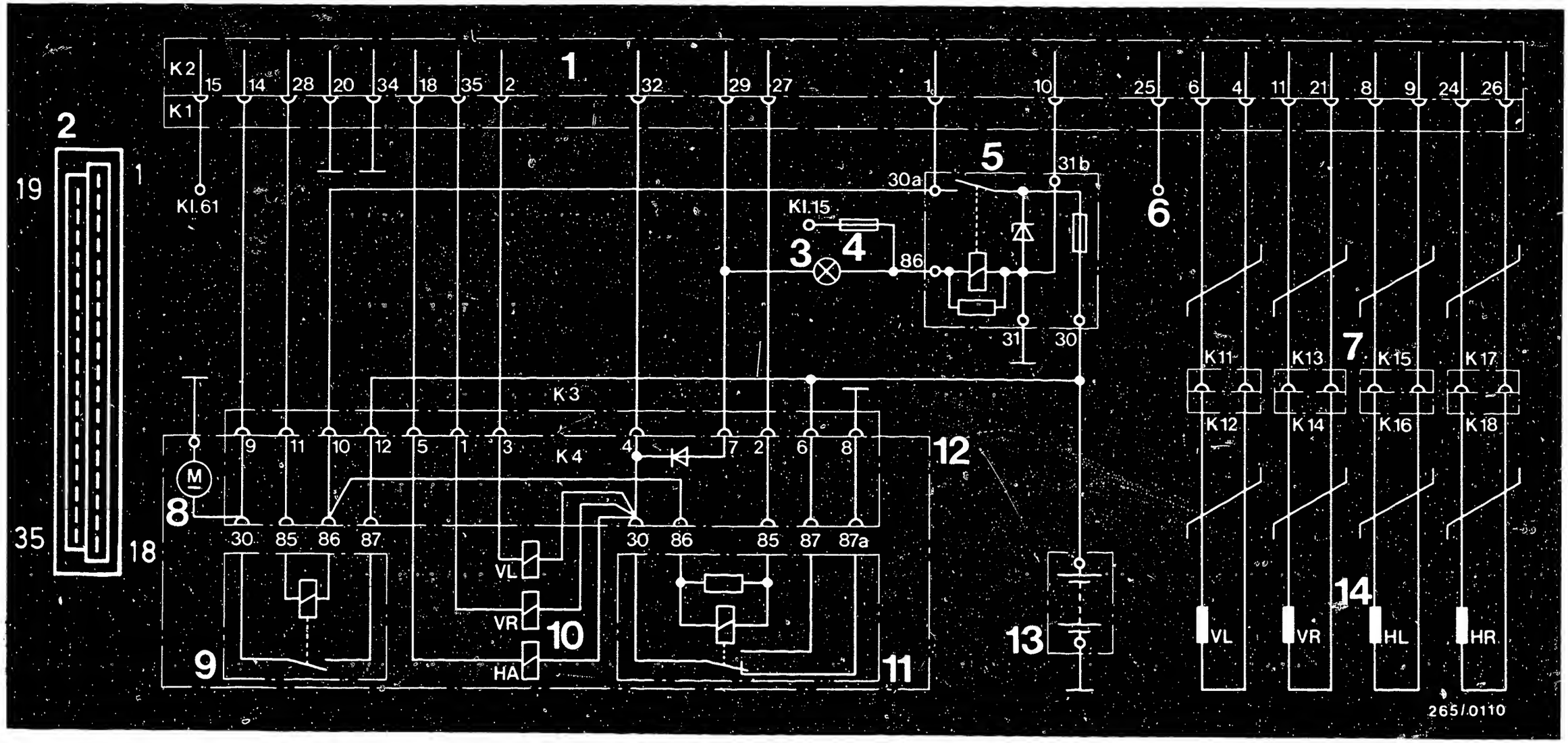
- Using the brake-pedal actuating device, press in brake pedal until a line pressure of 50 bar gauge pressure is produced. Then hold brake pedal in this position.

- During the test duration of 2 minutes the pressure drop must not be greater than 8 %. If there is a greater pressure drop, the leak (brake master cylinder, brake hoses, brake pipes, brake caliper) must be found and remedied, or the hydraulic modulator must be replaced.

Low-pressure test

- Release brake pedal actuating device until a line pressure of 2...5 bar gauge pressure is indicated on the pressure gauge.

- During a test duration of 5 minutes the set pressure must not drop more than 1 bar. If there is a greater pressure drop, the leak must be found and remedied, and the brake master cylinder or the hydraulic modulator must be replaced.



1 = Electronic controller
2 = Multiple plug (35-pin)
3 = ABS warning lamp
4 = Overvoltage protection relay
5 = Battery
6 = Fuse No. 6
7 = Cable connector
8 = Return-pump motor
9 = Return-pump relay
10 = Solenoid-operated valves
11 = Valve relay
12 = Hydraulic modulator
13 = Wheel-speed sensor
14 = To stop-lamp switch (+)

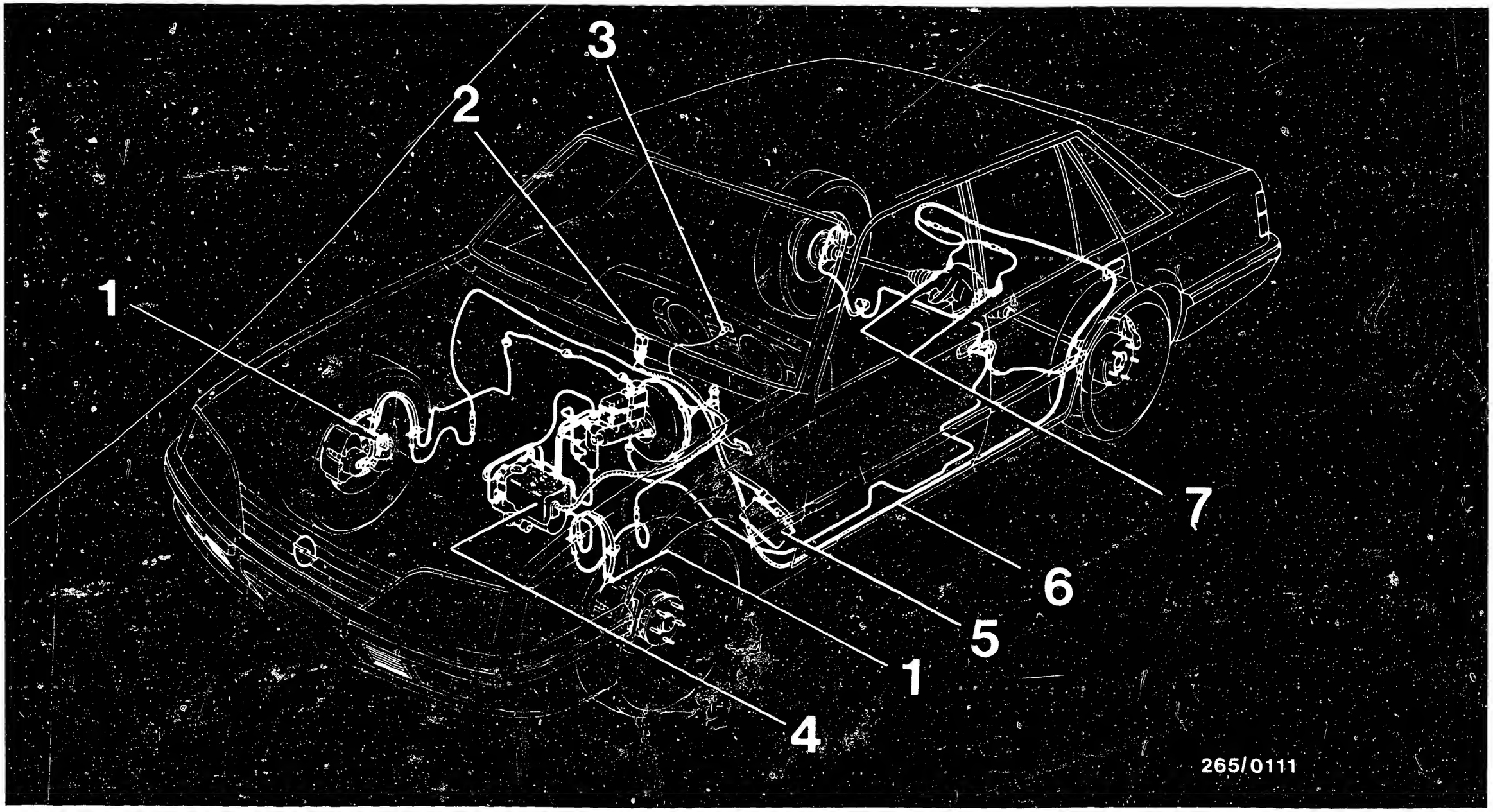
VL = Front left
VR = Front right
HA = Rear axle
HL = Rear left
HR = Rear right
K1 to K18 = ABS plug connectors

ELECTRICAL TERMINAL DIAGRAM FOR OPEL SENATOR / MONZA → 8.87

Installation position of components

The indications "right" and "left" always refer to the forward direction of travel.

- ABS warning lamp — in instrument panel.
- Front-axle wheel-speed sensors: — in steering knuckles on left and right.
- Rear-axle wheel-speed sensors: — on differential on left and right.
- Hydraulic modulator: — in engine compartment on left in front of brake master cylinder.
- Common ground terminal for ABS and LE-Jetronic: — in intake manifold at rear on cylinder 6, near firewall.
- Controller: — in driver's footwell behind left-hand side panel.
- Overvoltage protection relay: — in engine compartment on firewall on left-hand side.



1 = Front-axle wheel-speed sensor
2 = Overvoltage protection relay
3 = ABS warning lamp
4 = Hydraulic modulator
5 = Overvoltage protection relay
6 = ABS wiring harness integrated with LE-Jetronic wiring harness
7 = Rear-axle wheel-speed sensor

Installation position of components (continued)

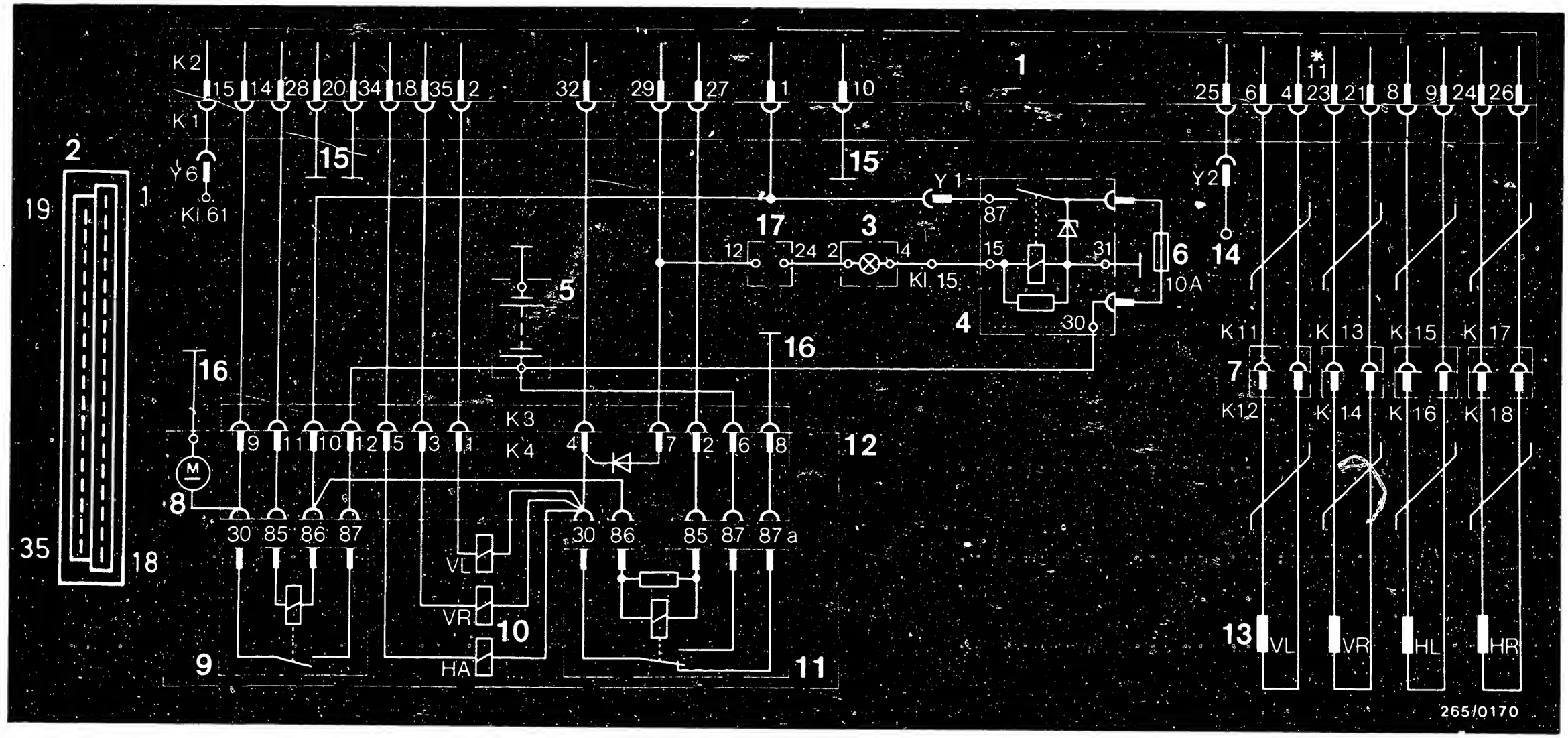
Leak test on brake system

	High-pressure test
Line test pressure gauge pressure	approx. 70 ... 90 bar
Test duration	approx. 10 minutes
Pressure drop from set value	0 %

Note
The leak test must be performed on both brake circuits.

Test procedure

- Connect pressure tester to fixed caliper. To do this, unscrew bleeder screw and screw in fitting. Then bleed pressure tester.
- Allow engine to run at medium speed and generate as high a vacuum as possible by suddenly releasing the accelerator pedal.
- Using the brake-pedal actuating device, press in the brake pedal until there is a line pressure between 70 and 90 bar gauge pressure. Then lock brake pedal in this position.
- During the test duration of 10 minutes there must be no pressure drop. If a pressure drop is found, then the leak must be sought and eliminated, or the hydraulic modulator must be replaced.



1 = Overvoltage protection relay
2 = Multiple plug (35-pin)
3 = ABS warning lamp in instrument cluster
4 = Overvoltage protection relay
5 = Battery
6 = Fuse
7 = Cable connector
8 = Return-pump motor
9 = Motor relay
10 = Solenoid-operated valve
11 = Valve relay
12 = Hydraulic modulator
13 = Wheel-speed sensor
14 = To stop-lamp switch (+)
15 = Ground terminal steering bracket
16 = Ground terminal on wheel house wall
17 = Central information panel
VL = Front left
VR = Front right
HL = Rear left
HR = Rear right
HA = Rear axle
K1 to K18 = ABS plug-in connections
Y1, Y2, Y6 = Connectors in central-electrics console

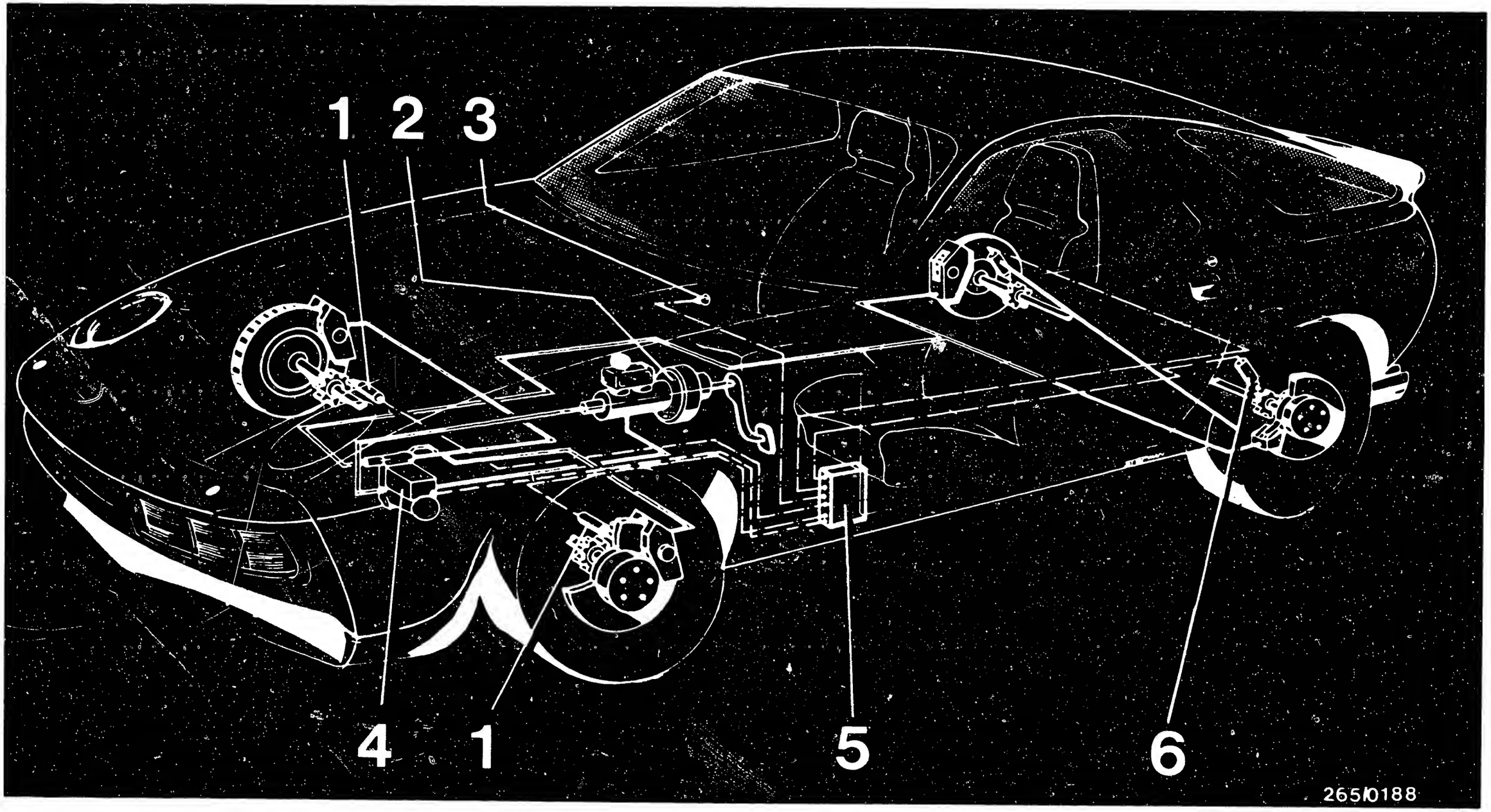
* Term. 11 as of 1986 model year (ring gears with 45 teeth)

ELECTRICAL TERMINAL DIAGRAM FOR PORSCHE 928 → 8.87

Installation position of components

The indications "left" and "right" always refer to the forward direction of travel.

• ABS warning lamp	In instrument cluster.
• Front-axle wheel-speed sensors:	One each on left and right in the steering knuckles.
• Rear-axle wheel-speed sensors:	One each on left and right in the wheel carrier.
• Hydraulic modulator:	In engine compartment at front left in a penetration of the wheelhouse wall.
• Ground terminal for ABS:	Under the steering bracket, near stop-lamp switch
• Controller:	In driver's footwell on left above the lid release handle.
• Overvoltage protection relay:	Relay no. 11 in central-electrics console.



1 = Front wheel-speed sensors
2 = Brake assembly with tandem master cylinder
3 = ABS warning lamp
4 = Hydraulic modulator
5 = Overvoltage protection relay
6 = Rear wheel-speed sensors

Installation posiiton of components (continued)

Checking the brake system for leaks

	High-pressure test	Low-pressure test
Line test pressure Gauge pressure	50 ... 100 bar	2 ... 5 bar
Test duration	10 minutes	5 minutes
Pressure drop of set value	10 % (max.)	0 %

Note
The leakage check, which must be performed in both brake circuits, comprises high-pressure and low-pressure testing.

High-pressure test

- Connect pressure tester to fixed caliper. To do this, unscrew bleeder screw and screw in fitting. Then bleed pressure tester.

- Allow engine to run at medium speed and generate as high a vacuum as possible by suddenly releasing the accelerator pedal.

- Using the brake-pedal actuating device depress the brake pedal until a line pressure of between 50 and 100 bar gauge pressure is generated, then secure brake pedal in this position.

- During the test period of 10 minutes, the pressure drop may not be greater than 10 % of the set value. If the pressure drop is greater than this figure the leak must be sought and eliminated, or the hydraulic modulator must be replaced.

Low-pressure test

- Release brake pedal actuating device until a line pressure of 2...5 bar gauge pressure is indicated on the pressure gauge.

- During a test period of 5 minutes the set pressure may not drop. If a drop in pressure is detected, the leak must be sought and eliminated, and the brake master cylinder or the hydraulic modulator must be replaced.

TEST CHART AND REPAIR INSTRUCTIONS FOR MERCEDES-BENZ VEHICLES AND VOLVO 740/760

Test prerequisites for testing with ABS 2-LED tester

- Specified tire size fitted?
- Check ground connection of return pump and of over-voltage protection relay term. 31 for security and corrosion.
- Visually examine hydraulic connections and joints on hydraulic modulator for leaks.
- If the ABS warning lamp comes on occasionally while driving (e.g. after switching on loads) and goes out again by itself, check battery and power supply (alternator, regulator and voltage drops).
- If the ABS warning lamp is constantly lit and does not go out, check the following points:
  - Multiple plug correctly seated on controller and latched?
  - All plug contacts O.K.?
  - Spring contacts latched?
  - Check proper installation position of seal ring in controller plug:
    curvature downwards.
  - **Check correct assignment of wheel-speed-sensor leads at controller plug.**
    Front left wheel-speed sensor to term. 6 and term. 4.
    Front right wheel-speed sensor to term. 23 and term. 21.
    Rear left wheel-speed sensor to term. 7 and term. 9.

- V-belt snapped?
  (No voltage supply from alternator, charge and ABS warning lamp lights up).

- To perform testing, switch on ignition in all program-selector switch settings (tester uses power supply from vehicle battery).

- Observe LED (green) for power supply in all program-selector switch settings.

- Connect ABS 2-LED tester to ABS wiring harness.

I M P O R T A N T !

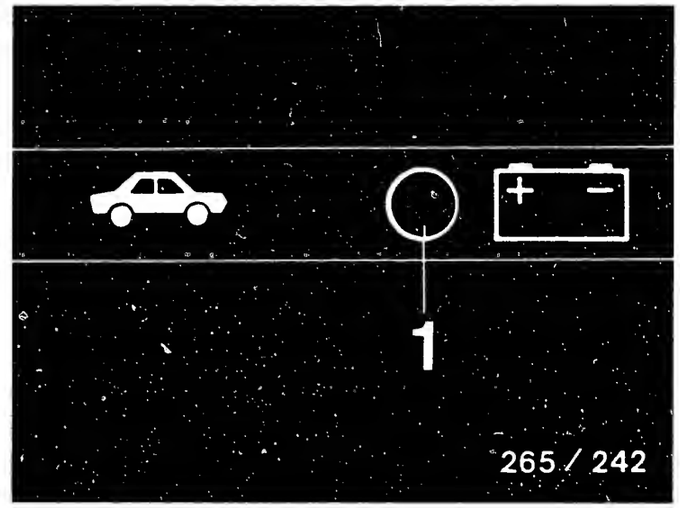
Only detach and attach controller with ignition switched off.
Never drive with tester connected!
The entire test program is to be repeated whenever repairs have been performed.
The antilock braking system is a vehicle safety system. Performing work on this system requires detailed system knowledge.
The conventional brake system must be in proper working order.

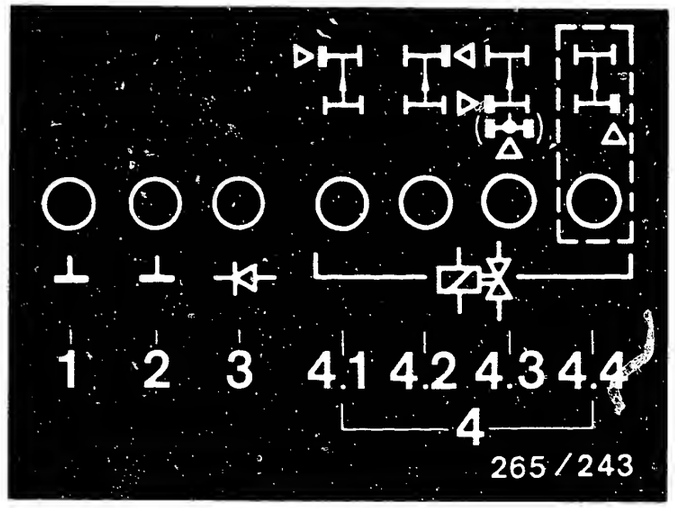
General information on trouble-shooting:

Test all leads for short-circuit to ground and contact with positive leads as well as for worn insulation and crushing.

Test chart for Mercedes-Benz vehicles and Volvo 740/760

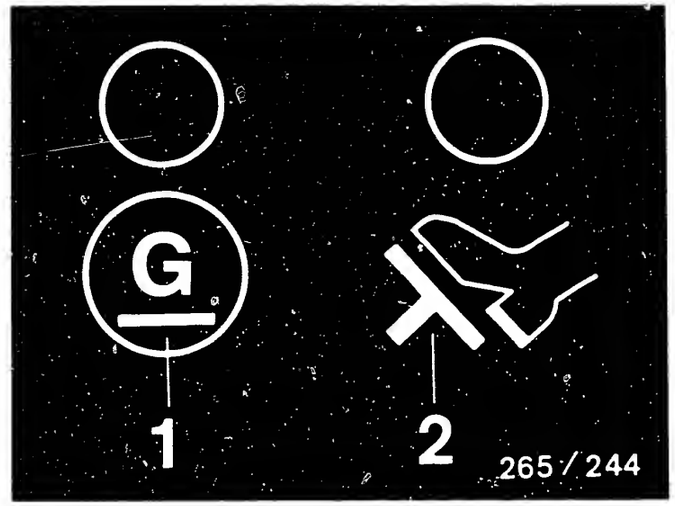
Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (reading)	Possible cause of trouble
all	Power supply (term. 20 and term. 1) for all test steps	Ignition on	LED (1) for battery voltage constantly lit (top diagram)	• Battery insufficiently charged • High voltage drops • Fuse defective • Overvoltage-protection relay defective • Check lead to ignition lock term. 15
1	Ground connections (term. 34, term. 10) Diode for warning lamp (term. 29, term. 32); solenoid-operated valve internal resistances (term. 2, term. 35, term. 18); off-position and ground connection of valve relay. ABS warning lamp.	Ignition on	6 LEDs (1, 2, 3, 4.1, 4.2, 4.3) lit with equal intensity (bottom diagram) ABS warning lamp in vehicle must light up.	• LEDs (1, 2) for ground connections not lit: Open circuit at ground terminals • LED (3) for warning lamp not lit: ABS warning lamp defective, diode defective • LED (4.1, 4.2 or 4.3) for solenoid-operated valve not lit: Check corresponding plug-in connection for solenoid-operated valve and leads. Internal resistance of solenoid-operated valve 0.7 ... 1.7 Ω. • All LEDs (4) for solenoid-op. valves and LED (3) for warning lamp not lit: Check valve relay ground connection, valve relay defective. • LEDs lit dimly: Contact resistance in corresponding circuit. • ABS warning lamp does not light up: warning lamp defective. Note: the other 6 LEDs light up.

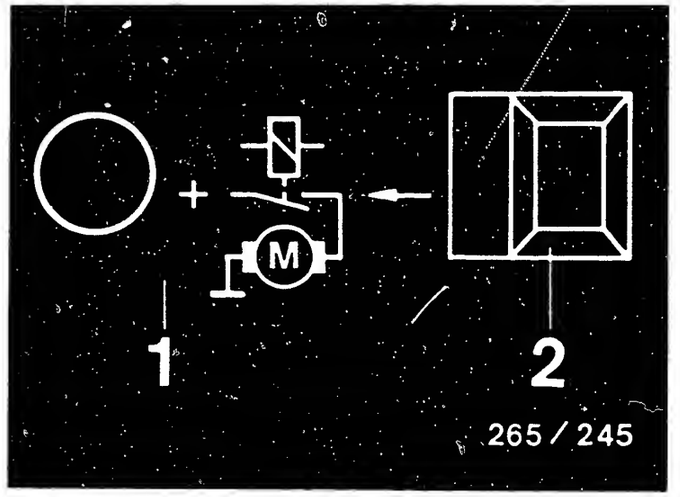




Test chart for Mercedes-Benz vehicles and Volvo 740/760

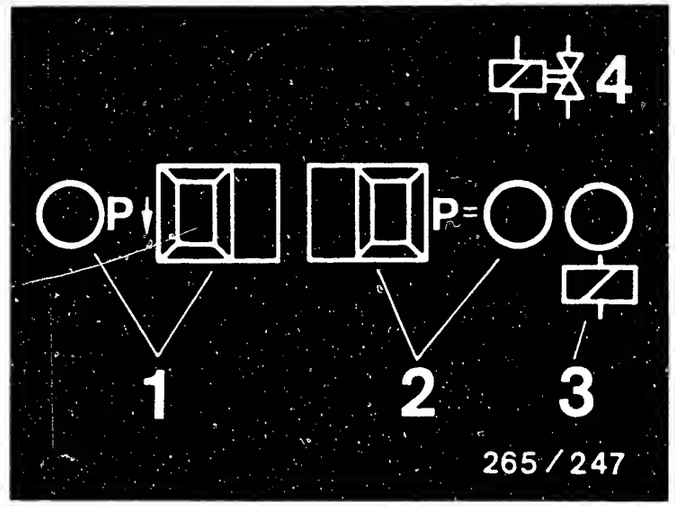
Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (reading)	Possible cause of trouble
2	Alternator voltage from term. 61 (term. 15), i.e. if there is a lead to term. 15)	Ignition on	LED (1) for alternator lit (top diagram)	• In some cases, LED (1) only goes out after burst of throttle (test is then O.K.) • Check lead to alternator term. 61 • Alternator defective
		Start engine	LED (1) goes out when engine running	
	Stop-lamp switch (term. 25), i.e. if there is a lead to term. 25)	Ignition on	LED (2) for stop-lamp switch lit	• Check lead to stop-lamp switch • Stop-lamp switch defective • Lead incorrectly connected to stop-lamp switch.
		Press brake pedal	LED (2) goes out	
3	Motor relay, pump motor in hydraulic modulator (term. 28)	Ignition on Press key (2) continuously	LED (1) lit, pump motor operating (bottom diagram)	Note: After releasing the key, LED (1) continues to light due to running-down of motor • Motor relay defective • Check ground connection of hydraulic modulator • Pump motor defective.

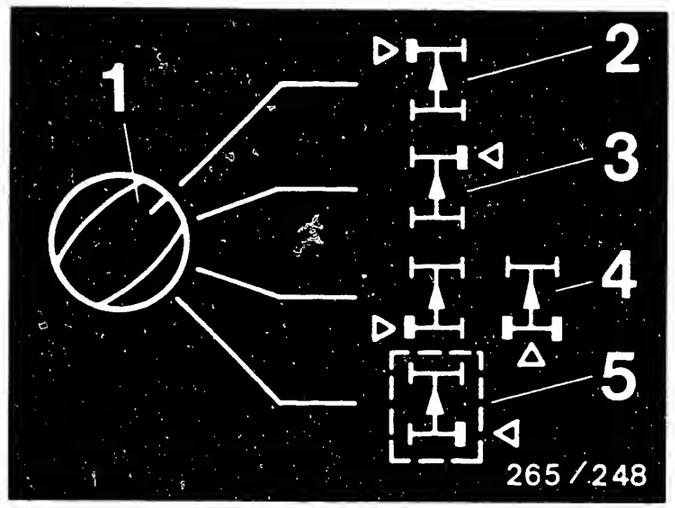




Test chart for Mercedes-Benz vehicles and Volvo 740/760

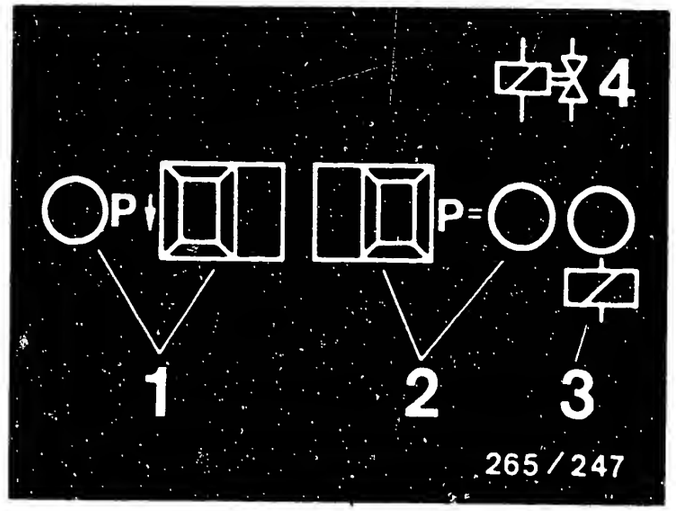
Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (reading)	Possible cause of trouble
4	Longitudinal acceleration sensor a_L (term.16) and transverse acceleration sensor a_Q (term.13)	Ignition on	not applicable	-----
5	Valve relay - operation (term. 27)	Ignition on	LED (3) for valve relay lit (top diagram)	• Test valve relay and leads to term. 85 and term. 86.
	Functional test and identity check of solenoid-operated valves in hydraulic modulator. Note: Perform test separately for each wheel one after the other. Testing on rear axle may be performed on left-hand or right-hand wheel.	Raise vehicle. Ignition on. The wheel under test must be freely rotatable by hand. Set wheel-selection switch to wheel under test (Items 2, 3, 4) (bottom diagram). Keep to sequence of operations.		





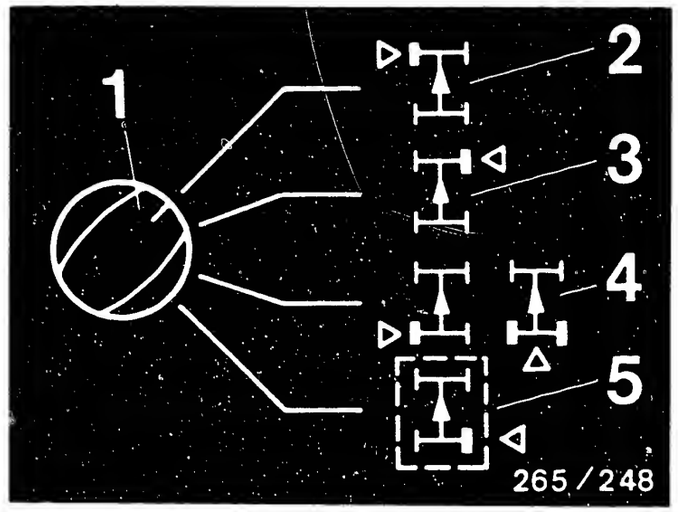
Test chart for Mercedes-Benz vehicles and Volvo 740/760

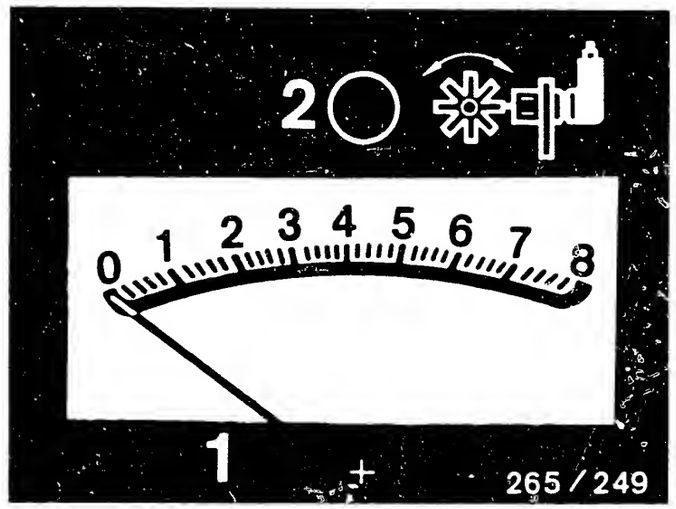
Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (reading)	Possible cause of trouble
5 (continued)	Pressure holding function	1. Press key P = (2) continuously	LED P = (2) lit (top diagram)	• Battery voltage too low: repeat test with engine running.
		2. Press brake pedal continuously	Wheel under test rotatable by hand	• Valve relay defective, open-circuit in lead from valve relay, term. 87 to B+,
		3. Release key P=(2)	LED P= (2) goes out, wheel locks	• brake lines mixed up at hydraulic modulator,
	Pressure reduction function	4. Press key P (1) for pressure reduction	LED (1) for pressure reduction lit, wheel rotatable by hand	• current value is not obtained (LED for pressure hold or pressure reduction goes out) because the battery is inadequately charged: repeat test with engine running.
		5. Release key P (1) for pressure reduction	LED (1) for pressure reduction goes out, wheel locks	• Hydraulic modulator defective.
		6. Release brake pedal		



Test chart for Mercedes-Benz vehicles and Volvo 740/760

Program switch position	Testing of (measurement at terminals)	Additional operation	Test specification (Reading)	Possible cause of trouble
6	Functional test and identity check of wheel-speed sensors. Note: Perform test individually for each front wheel one after the other. Test on rear axle may be performed on left-hand or right-hand wheel. (Front left wheel: term. 4 and term. 6; Front right wheel: term. 21 and term. 23; Rear axle: term. 7 and term. 9).	Raise vehicle. Ignition on. The wheel under test must be freely rotatable by hand. Set wheel-selection switch (top diagram) to the wheel under test. Turn wheel by hand until LED (No. 2 in bottom diagram) above the instrument lights up without flickering. (At approx. 1 revolution per second). Make reading on instrument.	Smallest reading: greater than 1.0 scale graduations. Allowable width of variation: max. 25% of highest reading.	• Wheel-speed sensor lead mixed up • Open circuit in wheel-speed sensor lead • Wheel-speed sensor defective, winding resistance DB up to 4.85: FL+FR: 0.9...2.3 kΩ RA: 0.6...1.6 kΩ DB as of 4.85: FL+FR: 0.6...1.6 kΩ RA: 0.6...1.6 kΩ all other models: 0.6...1.6 kΩ • Volvo: Detach ETC control unit and control unit for signal conversion and repeat test. • Air gap between wheel-speed sensor and ring gear too great. • Ring gear defective or loose. • Ring gear with incorrect number of teeth installed. DB front axle: 96 teeth. DB rear axle: differing number of teeth on propshaft, depending on gearing. Volvo: 96 teeth. • Wheel-bearing play too great.





Finally, perform a road test. With engine running, warning lamp must go out. In some cases, warning lamp goes out only after 6 km/h. Drive at at least 30 km/h. Warning lamp must not come on again.

Repair instructions for wheel-speed sensors

Removing the wheel-speed sensors on the front axle

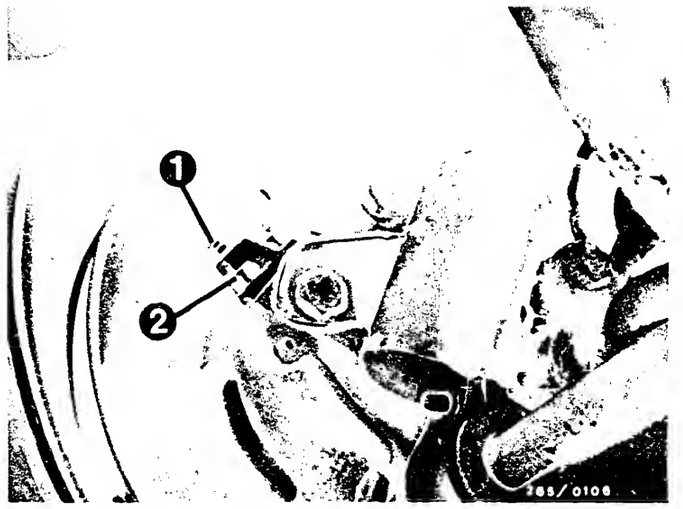
- Switch off ignition.
- Plug connector (top picture - arrow) in engine compartment or, on DB model W 201 in equipment space.
- Take apart plug connector in engine compartment or equipment space.
- Do not unscrew the wheel-speed sensor, but, if present (e.g. on Mercedes-Benz) the mounting plate and carefully pull out together with wheel-speed sensor. Do not use force!
- Release wheel-speed sensor lead from fastening points.

Mercedes-Benz:
Arrow = Wheel-speed sensor plug connector

Installing the wheel-speed sensors on the front axle

- Check O-ring for cracks and replace if necessary.
- Take new wheel-speed sensor out of protective sleeve only when ready to install.
- Grease wheel-speed sensor housing with Molykote Longterm 2.
- Before installing the wheel-speed sensors, make sure that there are no metallic foreign bodies on the permanently magnetic edges.
- Press wheel-speed sensor into mounting hole. Do not knock. Do not damage O-ring.
- Secure wheel-speed sensors with new micro-encapsulated screws. Tighten fastening screws to 22 Nm on Mercedes with mounting plate and to 6 ... 8 Nm on Mercedes without mounting plate.
- Re-attach wheel-speed sensor leads at the points provided.

Mercedes-Benz:
1 = Wheel-speed sensor
2 = Mounting plate



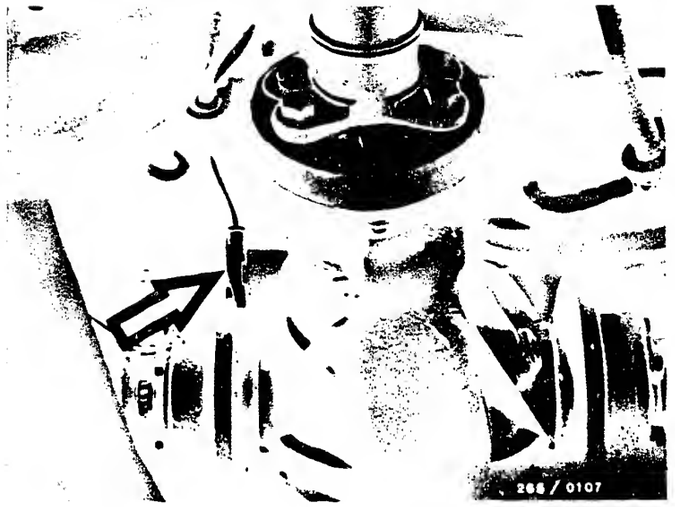
Repair instructions for wheel-speed sensors (continued)

Removing the wheel-speed sensors on the rear axle

- Switch off ignition.
- Take apart wheel-speed sensor plug connector (under rear seat on Mercedes, in luggage compartment on Volvo).
- Release wheel-speed sensor lead from fastening points.
- Loosen fastening screw and pull out wheel-speed sensor.
  Do not use force.
  On Volvo, do not lose shim; is used for re-installation.

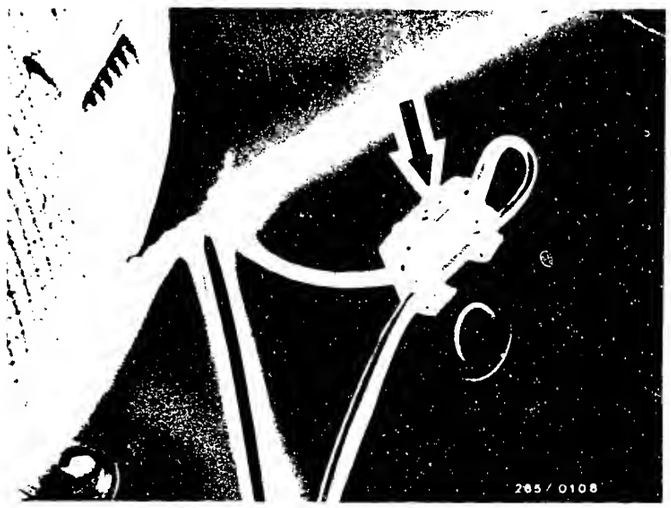
Installing the wheel-speed sensors on the rear axle

- Check O-ring for cracks and replace if necessary.
- Take new wheel-speed sensor out of protective sleeve only when ready to install.
- Grease wheel-speed sensor housing with Molykote Longterm 2.
- Before installing the wheel-speed sensors, make sure that there are no metallic foreign bodies on the permanently magnetic edges.
- Press wheel-speed sensor into mounting hole. Do not knock.
  Do not damage O-ring.
- Secure wheel-speed sensors with new micro-encapsulated screws. Tighten fastening screws to 6 ... 8 Nm.
- Re-attach wheel-speed sensor leads at the points provided.



Mercedes-Benz:
Arrow = Wheel-speed sensor

Mercedes-Benz:
Arrow = Wheel-speed sensor plug connector under right-hand rear seat bench



Repair instructions for wheel-speed sensors

Installing the wheel-speed sensors on the rear axle (continued)

Volvo only:

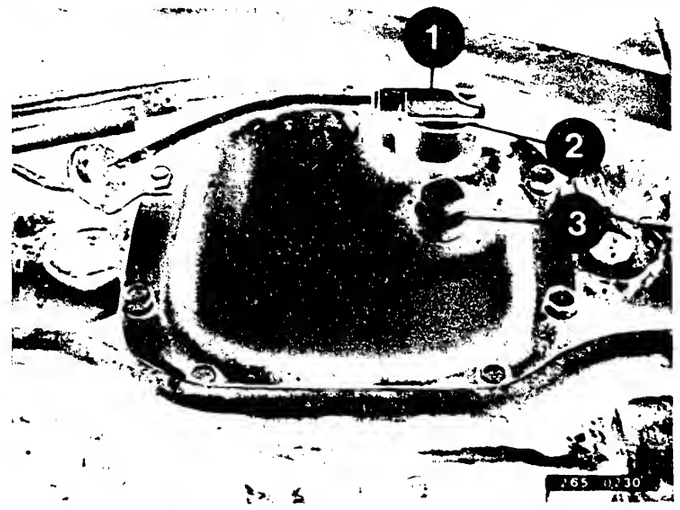
- Using feeler gauge, measure air gap between wheel-speed sensor edge and ring gear.
  Specification 0.35 ... 0.75 mm.

  If necessary, correct air gap to nominal dimension 0.6 mm with shims.

  To measure the air gap, remove the oil-drain plug and introduce the feeler gauge as shown.

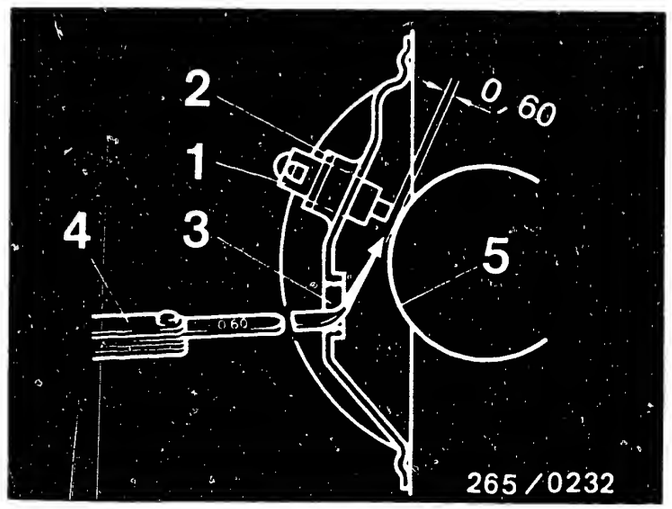
  Turn the drive bevel gear slightly.

  Shims are available from Volvo dealers in thicknesses from 1.0 ... 1.8 mm in steps of 0.2 mm.



Volvo:
1 = Wheel-speed sensor in rear-axle housing
2 = Shim
3 = Oil-drain plug

Volvo:
1 = Wheel-speed sensor
2 = Shim
3 = Oil-drain plug
4 = Feeler gauge
5 = Drive bevel gear



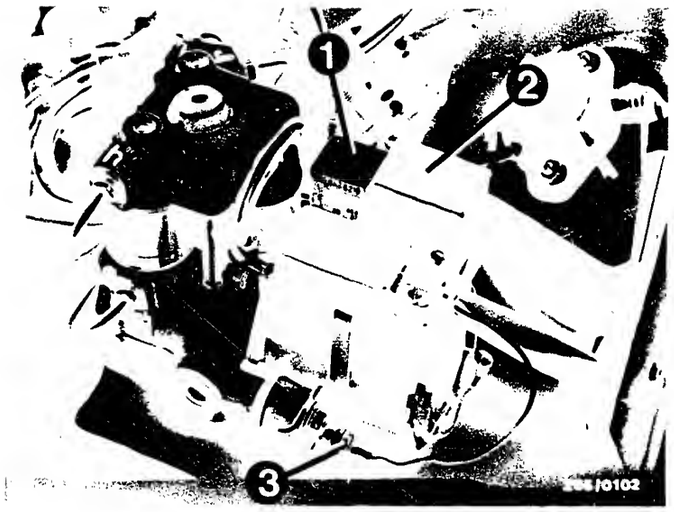
Repair instructions for hydraulic modulators

Removing the hydraulic modulator

- For safety reasons, the hydraulic modulator must not be repaired, but the complete unit must be replaced.
  Exceptions to this are the return-pump relay and the valve relay. Both relays may be replaced.

- Apart from the brake-line connections, it is not permissible to loosen any screws on the hydraulic modulator. In particular the hexagon-socket-head cap screws (bottom picture - arrows) may under no circumstances be loosened. After loosening, it is no longer possible to get the brake circuits leak-tight.
  Danger!

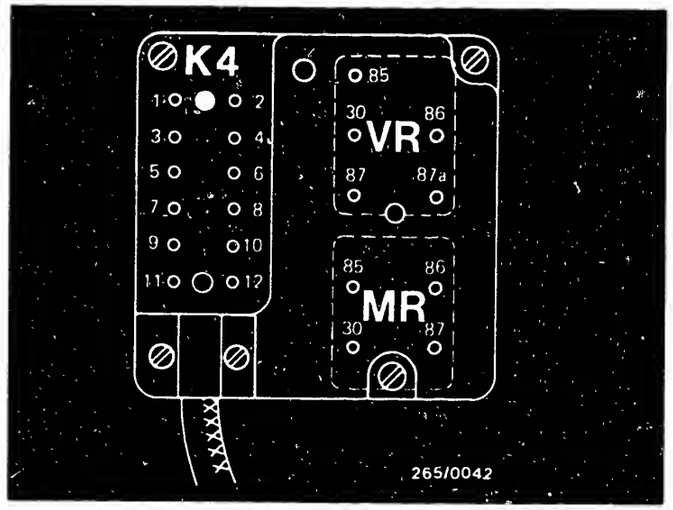
- Check the hydraulic modulator and brake-line connections for leaks by means of a visual examination. If brake fluid is escaping, tighten the brake-line connections (12...16 Nm) or replace, or replace the hydraulic modulator.



1 = Valve relay
2 = Motor relay
3 = Ground terminal

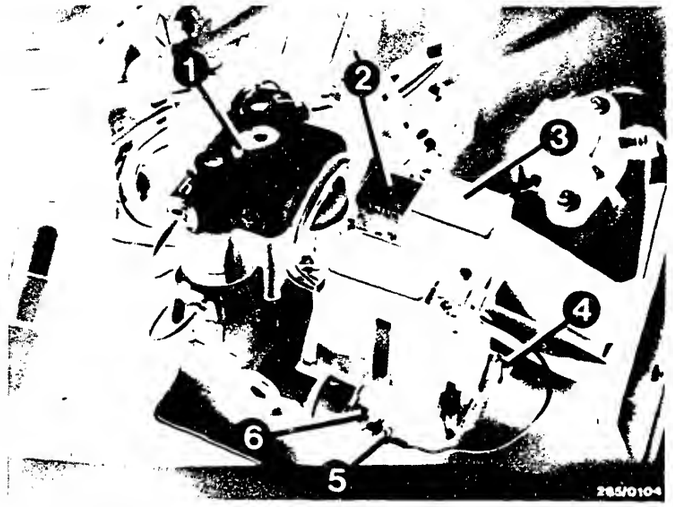
Top view of plug-in plate of hydraulic modulator

VR = Valve relay
MR = Motor relay
K4 = Wiring-harness plug



Repair instructions for hydraulic modulators (continued)

- Use only the specified double-end flare nut wrench 9x11 mm for loosening and tightening the brake lines.
- Mark brake lines and remove from hydraulic modulator.
- Catch the brake fluid and do not bring it into contact with your skin or clothing or with paintwork.
- Immediately seal the brake lines and connections with dummy plugs.
- Disconnect ground cable from pump motor.
- Loosen fastening screw and remove cover.
- Loosen bracket and remove plug.
- Loosen hexagon nuts from holder and remove hydraulic modulator.

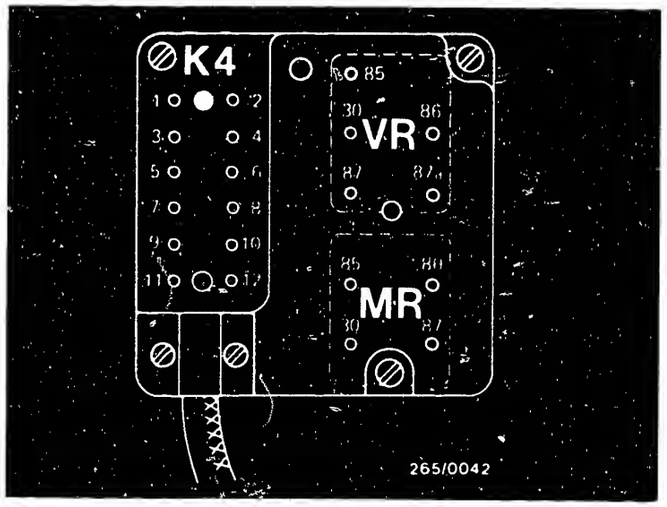


1 = Hydraulic modulator
2 = Valve relay
3 = Motor relay
4 = Pump motor ground terminal
5 = Valve relay ground terminal
6 = Fastening

Installation

- Mount hydraulic modulator in the holder and fasten with the hexagon nuts.
- Connect ground cable to pump motor. Plug on 13-pin plug and fasten with the bracket (4,5).
- Fasten cover on the hydraulic modulator with the screw.
- Connect the brake lines to the hydraulic modulator in accordance with the markings.
- Observe the tightening torque for the brake-line connections on the hydraulic modulator: 12...16 Nm.
- Bleed the brake system and check for leaks.
- Fully test the ABS with the tester.
- Completely check ABS with tester.

Top view of plug-in plate of hydraulic modulator
VR = Valve relay
MR = Motor relay
K4 = Wiring-harness plug



Repair instructions (continued)

Pay particular attention to the joint identified by arrows (bottom picture).

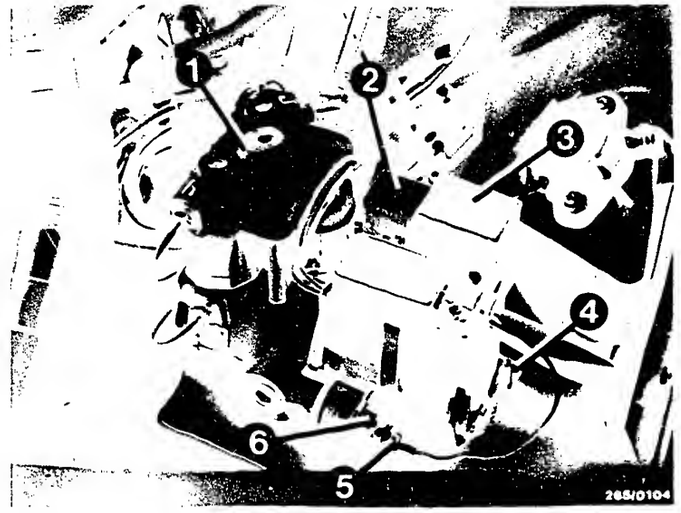
On the base of the hydraulic modulator there is a vent hole to the pump pistons. A slight escape of brake fluid is possible at this point.

A complaint is only justified if, after pressing the brake pedal several times, a pool of brake fluid is formed under the hydraulic modulator.

- When removing and installing the brake lines, make sure that the lines are marked in accordance with the markings on the hydraulic modulator and that they are not mixed up when re-connecting (e.g. FL of hydraulic modulator must be connected to the front left wheel brake cylinder).

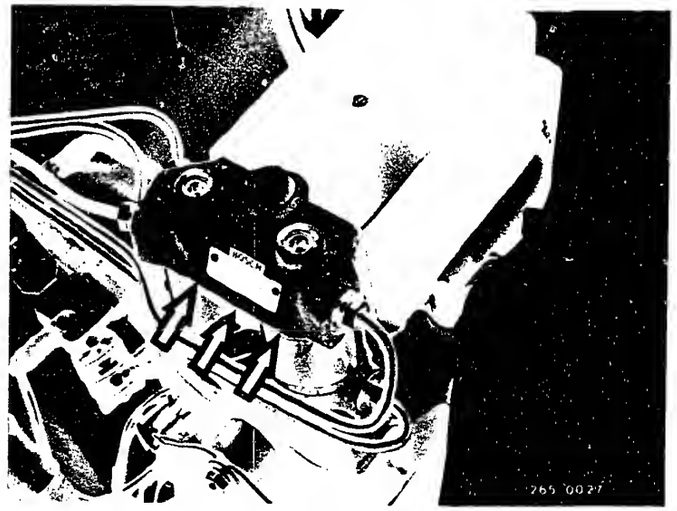
- Markings on hydraulic modulator

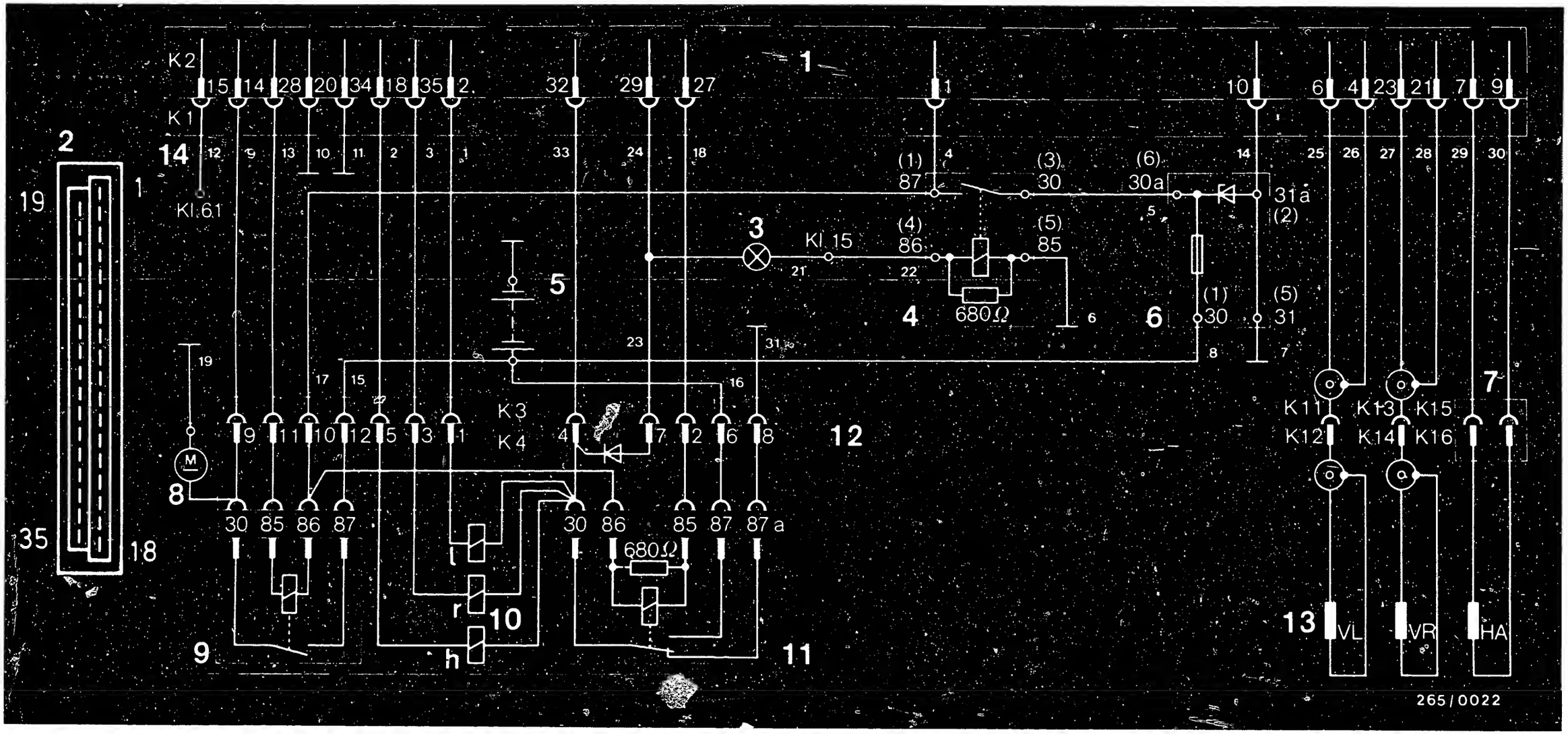
vl	l	=	Connection for brake line, front left (wheel-brake cylinder)
vr	r	=	Connection for brake line, front right (wheel-brake cylinder)
h	h	=	Connection for brake line of rear axle
V	V	=	Front-axle brake circuit from brake master cylinder
H	H	=	Rear-axle brake circuit from brake master cylinder



1 = Hydraulic modulator
2 = Valve relay
3 = Motor relay
4 = Pump motor ground terminal
5 = Valve relay ground terminal
6 = Fastening

Arrows = Joints

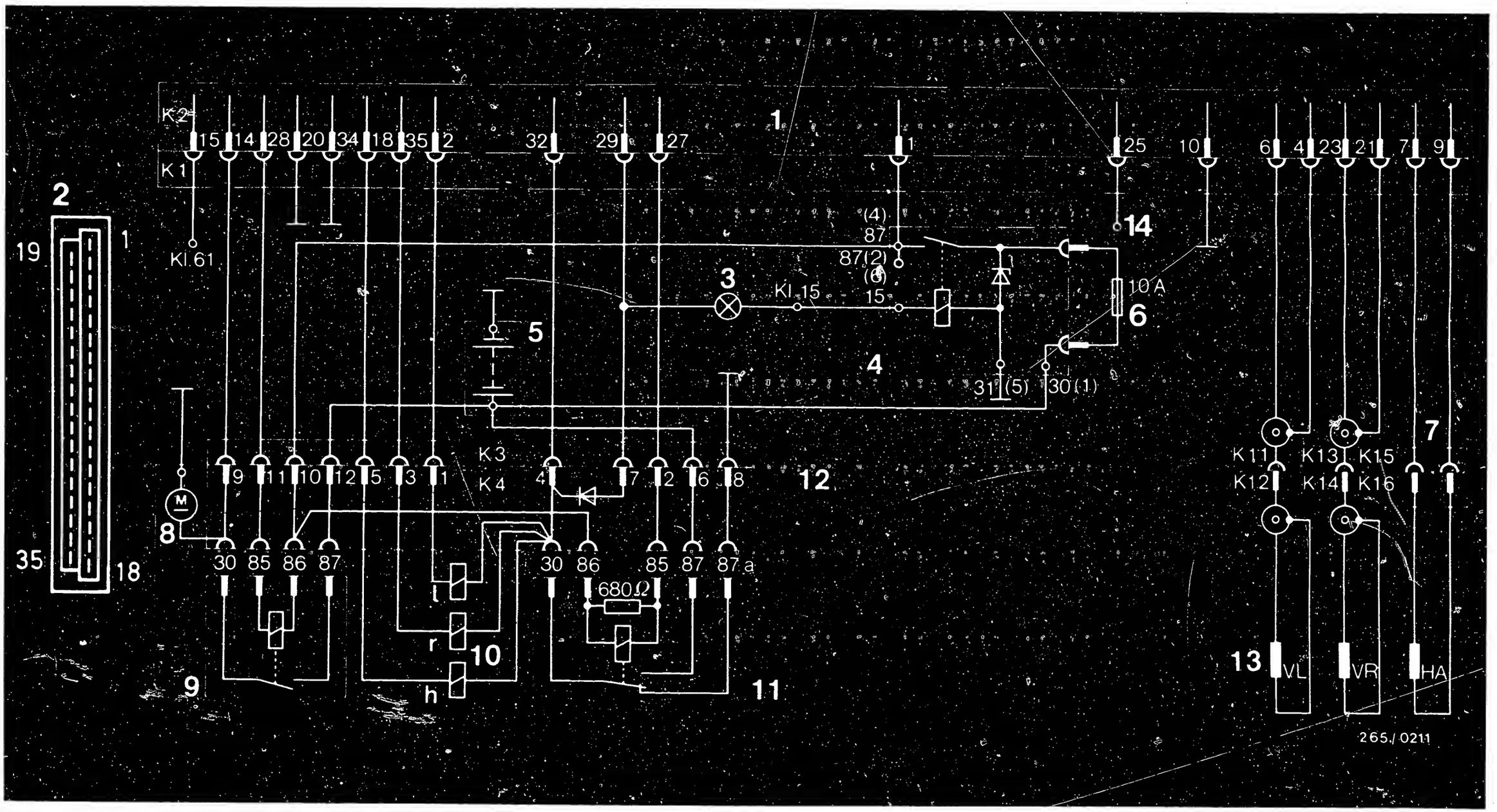




1 = Controller
2 = Multiple plug (35-pin)
3 = ABS warning lamp
4 = Relay for controller
5 = Battery
6 = Overvoltage protection
7 = Cable connector
8 = Return-pump motor
9 = Motor relay
10 = Solenoid-operated valves
11 = Valve relay
12 = Hydraulic modulator
13 = Wheel-speed sensor
14 = If there is a lead to the alternator term. 61/D+

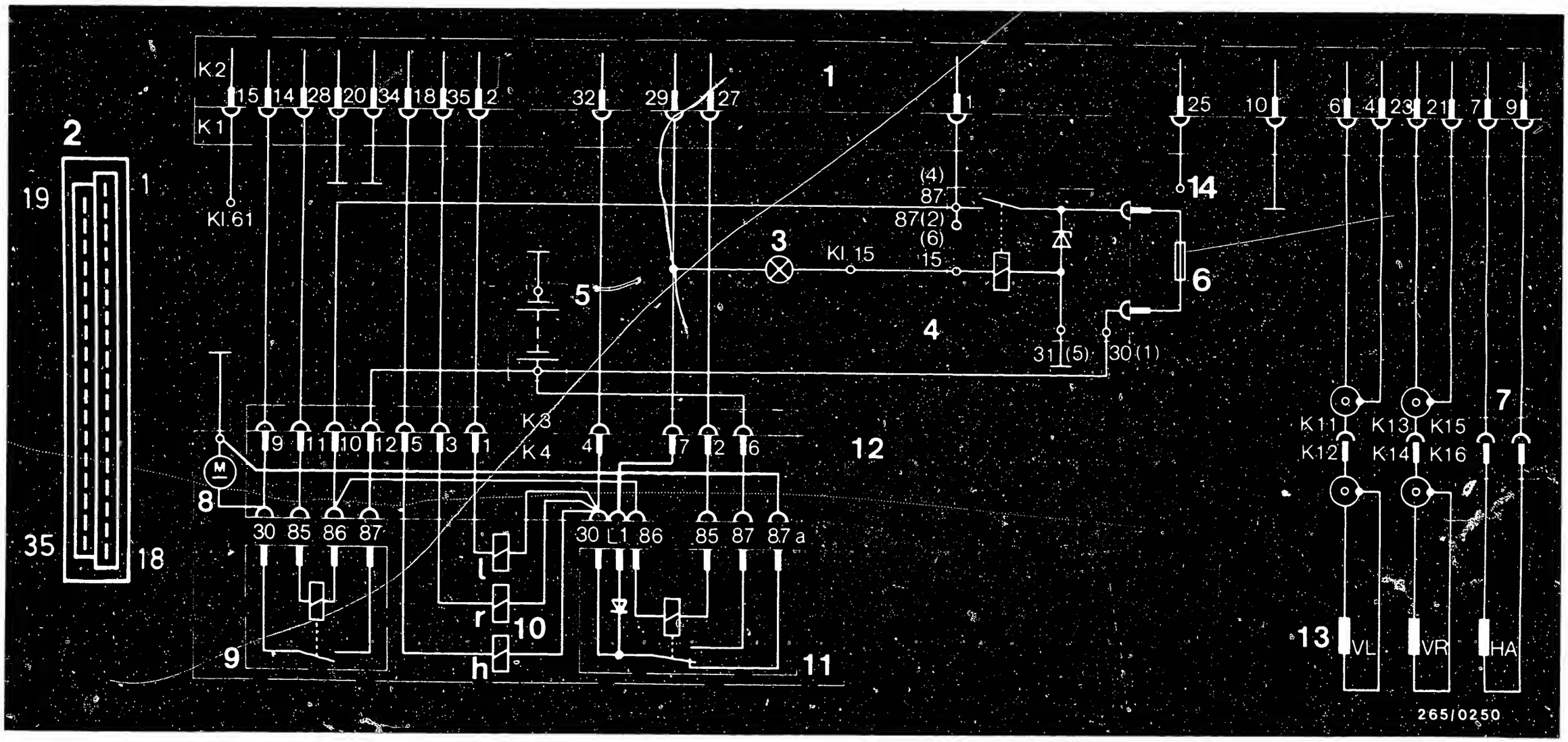
l = VL = Front left
r = VR = Front right
h = HA = Rear axle
K1 to K16 = ABS plug connectors
1 = (Numbers in circles) = Cable numbers

ELECTRICAL TERMINAL DIAGRAM FOR MERCEDES-BENZ MODELS 107 / 116 / 123 / 126 (→ 9.81)



1 = Controller
2 = Multiple plug (35-pin)
3 = ABS warning lamp
4 = Overvoltage protection relay
5 = Battery
6 = Fuse
7 = Cable connector
8 = Return-pump motor
9 = Motor relay
10 = Solenoid-operated valves
11 = Valve relay
12 = Hydraulic modulator
13 = Wheel-speed sensor
14 = to stop-lamp switch (+)
l = Front left
r = Front right
h = Rear axle
K1 to K16 = ABS plug connectors

Electrical terminal diagram for Mercedes-Benz models 107 / 116 / 123 / 126 (9.81 → 9.85) (Gradual change-over)



1 = Controller
2 = Multiple plug (35-pin)
3 = ABS warning lamp
4 = Overvoltage protection relay
5 = Battery
6 = Fuse 10 A
7 = Cable connector
8 = Return-pump motor
9 = Motor relay
10 = Solenoid-operated valves
11 = Valve relay
12 = Hydraulic modulator
13 = Wheel-speed sensor
14 = to stop-lamp switch (+)
l = Front left
r = Front right
h = Rear axle
K1 to K16 = ABS plug connectors

Electrical terminal diagram for Mercedes-Benz vehicles (as of 8.85) (Gradual change-over)

Installation position of components

The indications "right" and "left" always apply as viewed in the forward direction of travel.

- ABS warning lamp:
  In instrument panel.

- Front-axle wheel-speed sensors:
  One each on left and right in the steering knuckles.

- Rear-axle wheel-speed sensor:
  One on the rear-axle housing (under rear seat).

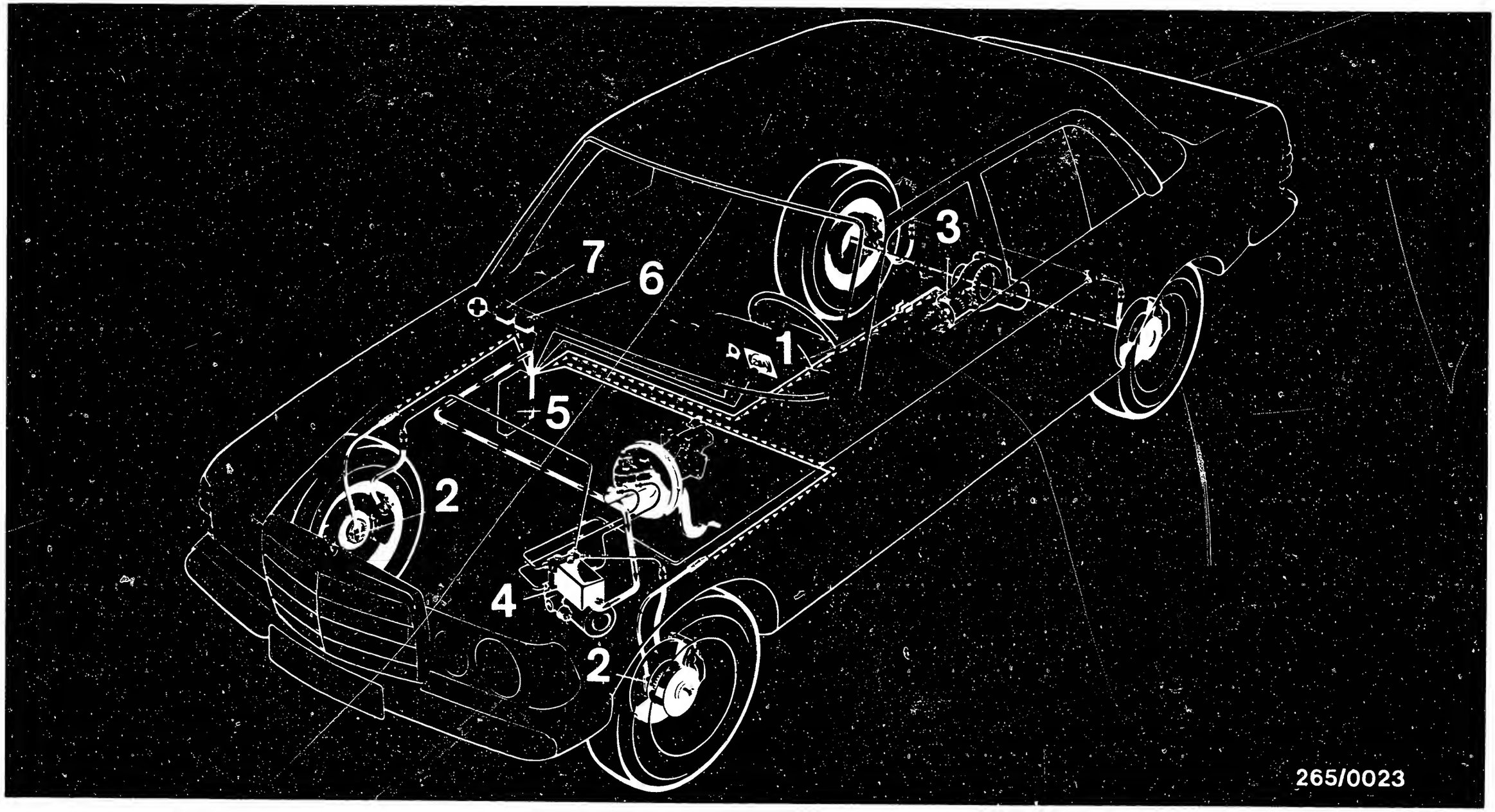
- Hydraulic modulator:
  In engine compartment on left in front of brake master cylinder.

- Ground terminals for ABS:
  Models 107 and 116:
  Behind the right-hand footwell panel.
  Models 123 and 126:
  Behind the instrument panel, to right of steering column.

- Controller:
  Model 107: Behind right-hand footwell support.
  Models 116
  and 123 : Behind right-hand footwell panel.
  Model 126: In equipment space between wiper motor.

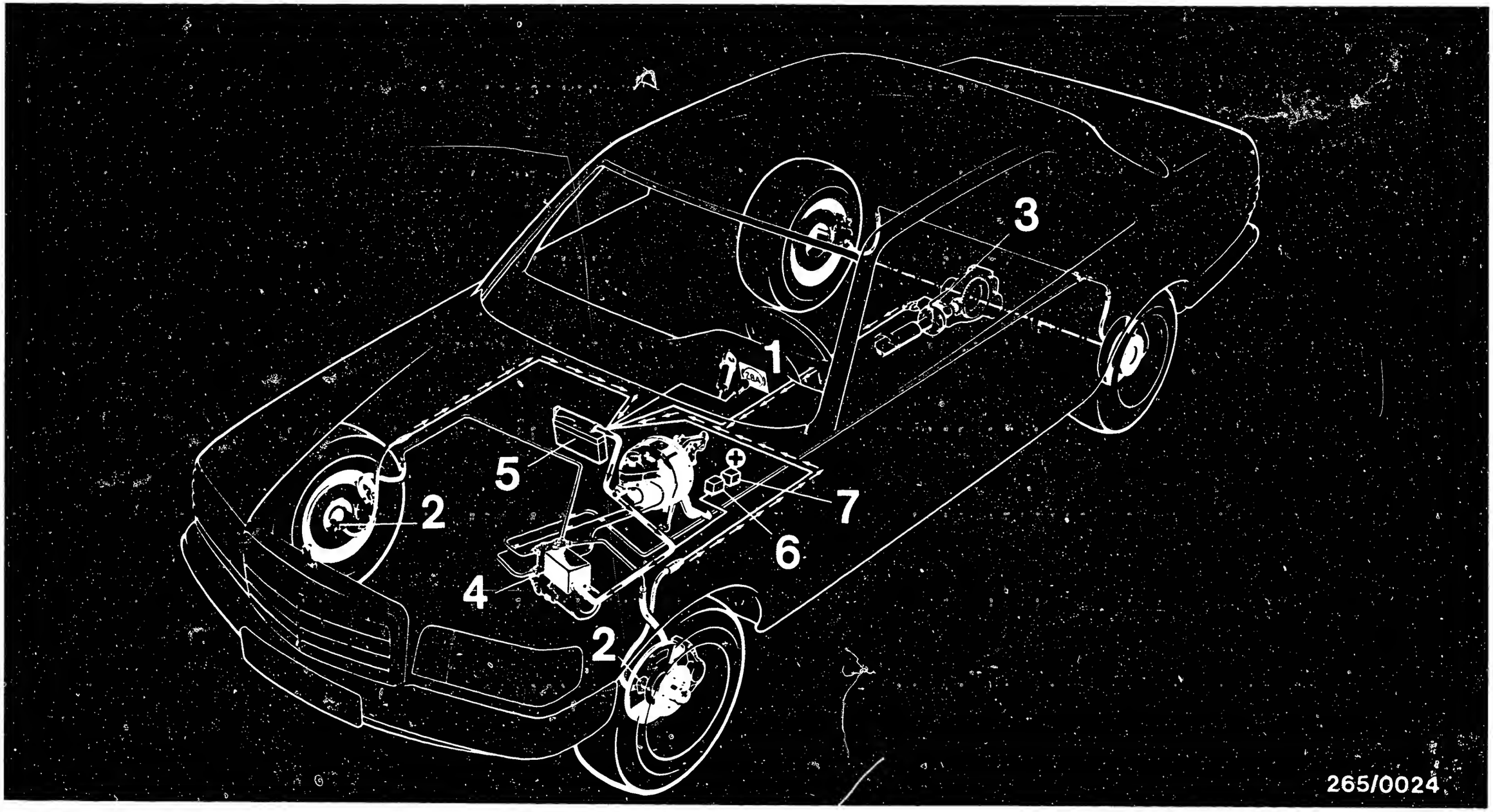
- Relay for controller:
  Model 107: Behind right-hand footwell panel.
  Model 116: Under glove compartment.
  Model 123: Behind glove compartment panel.
  Model 126: In fuse box in equipment space.

- Overvoltage protection:
  Model 107: Behind right-hand footwell panel.
  Model 116: Behind right-hand footwell panel next to controller.
  Model 123: Behind glove compartment panel
  Model 126: In fuse box in equipment space.



1 = ABS warning lamp
2 = Front-axle wheel-speed sensor
3 = Rear-axle wheel-speed sensor
4 = Hydraulic modulator
5 = Controller
6 = Relay for controller
7 = Overvoltage-protection relay

Installation position of components in models 200 D - 280 E (W 123, W 116 similar)



1 = ABS warning lamp
2 = Front-axle wheel-speed sensor
3 = Rear-axle wheel-speed sensor
4 = Hydraulic modulator
5 = Controller
6 = Relay for controller
7 = Overvoltage-protection relay

Installation position of components in vehicles of "S" class (W 126)

Installation position of components

The indications "right" and "left" always apply as viewed in the forward direction of travel.

- ABS warning lamp:
  In instrument panel.

- Front-axle wheel-speed sensors:
  One each on left and right in the steering knuckles.

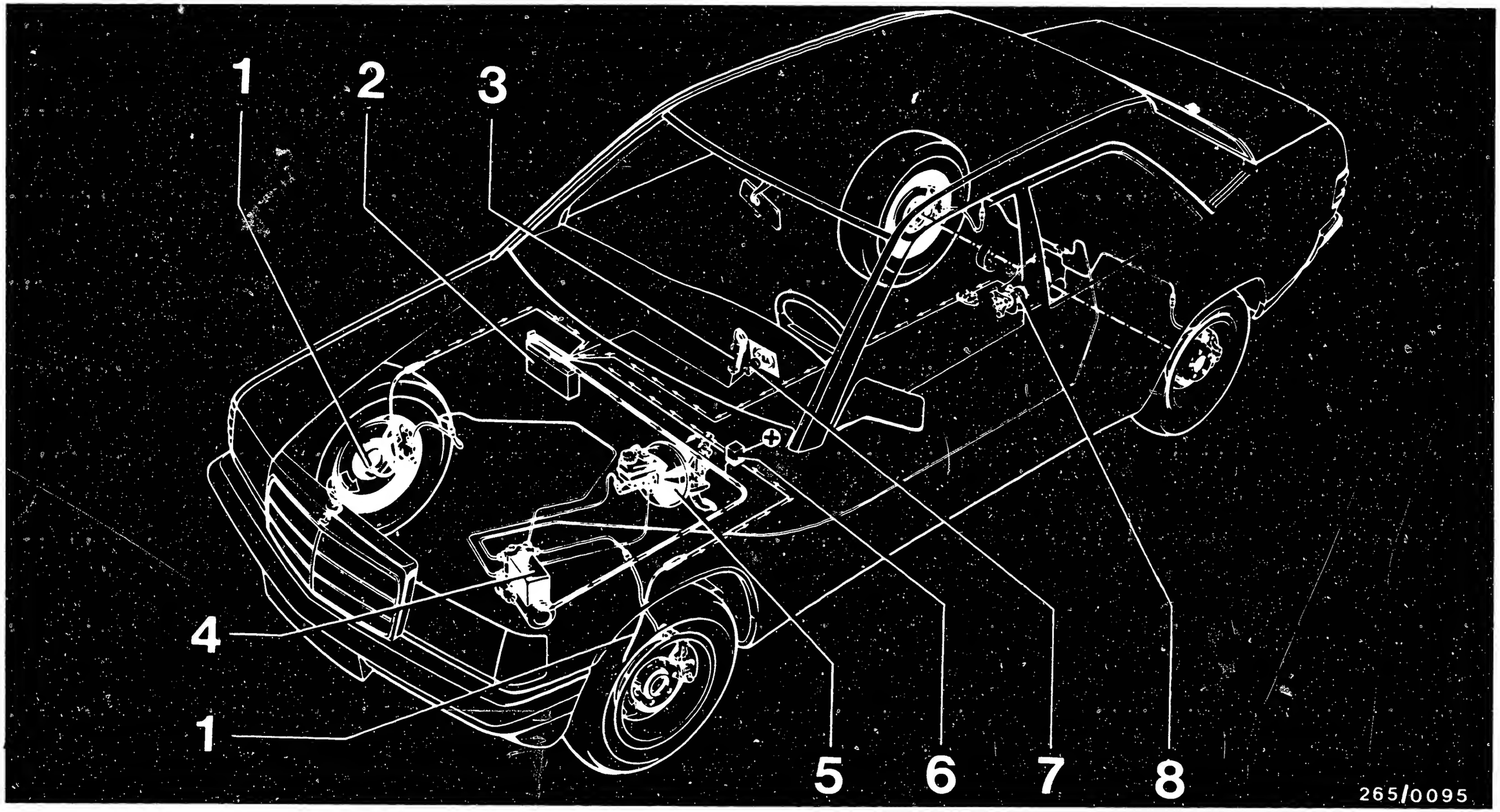
- Rear-axle wheel-speed sensor:
  Only 1 wheel-speed sensor on rear-axle housing.

- Hydraulic modulator:
  In engine compartment at front left.

- Ground terminal for ABS:
  Behind instrument cluster, bottom left, near plug-in connections of central-electrics box.

- Controller:
  In equipment space on right, behind battery.

- Overvoltage-protection relay:
  In fuse box (in equipment space on left).



1 = Front-axle wheel-speed sensor
2 = Controller
3 = Steering lock
4 = Hydraulic modulator
5 = Brake assembly with brake master cylinder
6 = Overvoltage-protection relay
7 = Warning lamp
8 = Rear-axle wheel-speed sensor

Installation position of components (continued)

Checking the brake system for leaks

	High-pressure test	Low-pressure test
Line test pressure Gauge pressure	50 ... 90 bar	3 bar
Test duration	5 minutes	2 minutes
Pressure drop of set value	5 % (max.)	0 %

Note
The leakage check, which must be performed in both brake circuits, comprises high-pressure and low-pressure testing.

High-pressure test

- Connect pressure tester to fixed caliper. To do this, unscrew bleeder screw and screw in fitting. Then bleed pressure tester.

- Allow engine to run at medium speed and generate as high a vacuum as possible by suddenly releasing the accelerator pedal.

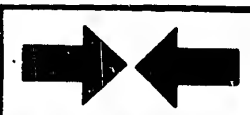
- Using the brake-pedal actuating device, press in brake pedal until a line pressure of 50...90 bar gauge pressure is produced. Then hold brake pedal in this position.

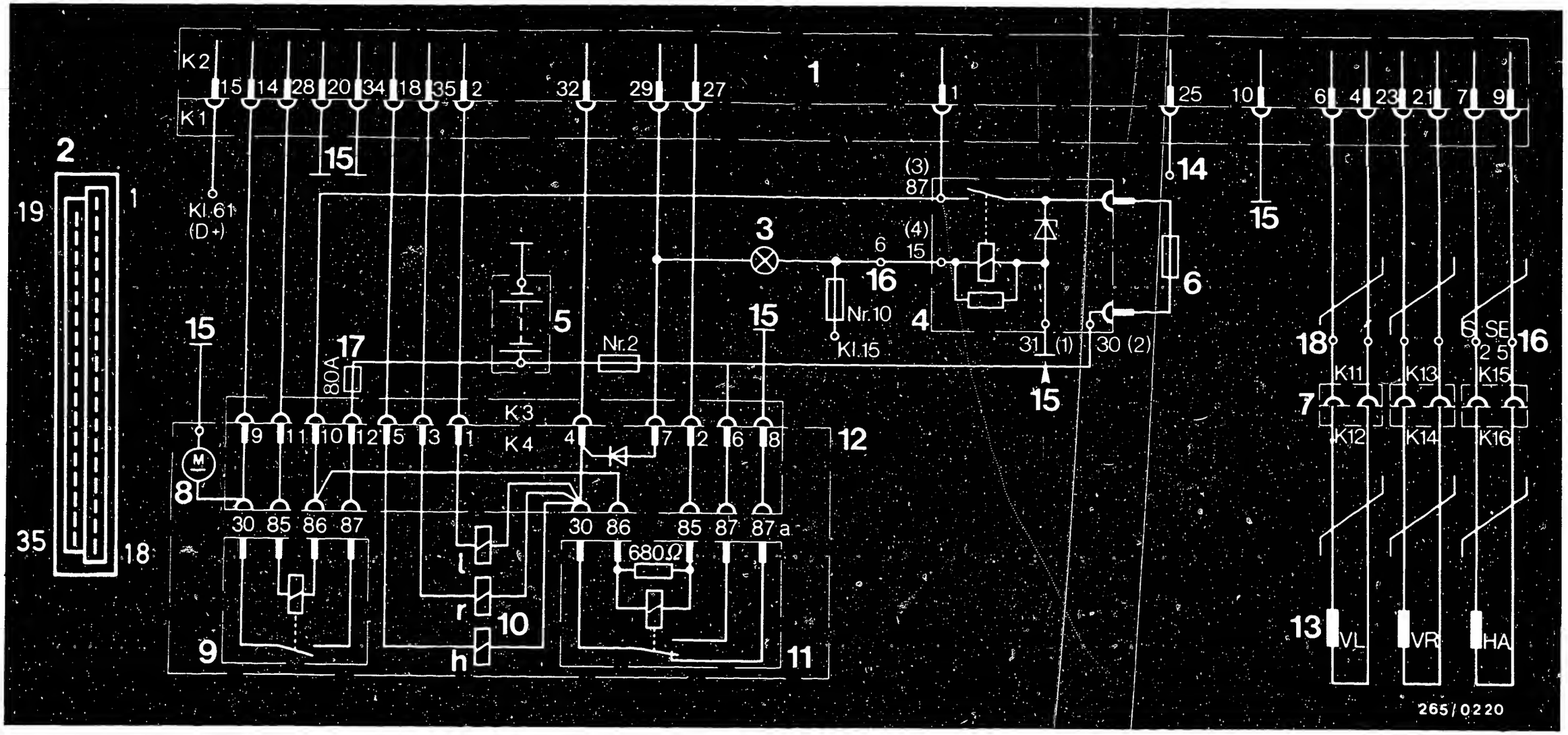
- During the test duration of 5 minutes the pressure drop must not be greater than 5 %. If there is a greater pressure drop, the leak (brake master cylinder, brake hoses, brake pipes, brake caliper) must be found and remedied, or the hydraulic modulator must be replaced.

Low-pressure test

- Release brake pedal actuating device until a line pressure of 3 bar gauge pressure is indicated on the pressure gauge.

- During a test duration of 2 minutes the set pressure must not drop more than 1 bar. If there is a greater pressure drop, the leak must be found and remedied, and the brake master cylinder or the hydraulic modulator must be replaced.





1 = Controller
2 = Multiple plug (35-pin)
3 = ABS warning lamp
4 = Overvoltage-protection relay
5 = Battery
6 = Fuse 10 A
7 = Cable connector
8 = Return-pump motor
9 = Motor relay
10 = Solenoid-operated valves
11 = Valve relay
12 = Hydraulic modulator
13 = Wheel-speed sensor
14 = to stop-lamp switch (+)
15 = Ground terminal on right-hand rear lamp
16 = Terminals on signal converter
17 = Fuse box
18 = Terminals on ETC control unit (if applicable)

l = VL = Front left
r = VR = Front right
h = HA = Rear axle

K1 to K16 = ABS plug connectors

ELECTRICAL TERMINAL DIAGRAM FOR VOLVO 740/760 → 8.86

Installation position of components

The indications "right" and "left" always apply as viewed in the forward direction of travel.

- ABS warning lamp:
  In instrument panel.

- ABS fuse box:
  In engine compartment on right-hand spring-strut crown.

- Front-axle wheel-speed sensors:
  One each on left and right in the steering knuckles.

- Rear-axle wheel-speed sensor:
  Only 1 wheel-speed sensor on rear-axle housing.

- Hydraulic modulator:
  In luggage compartment on right.

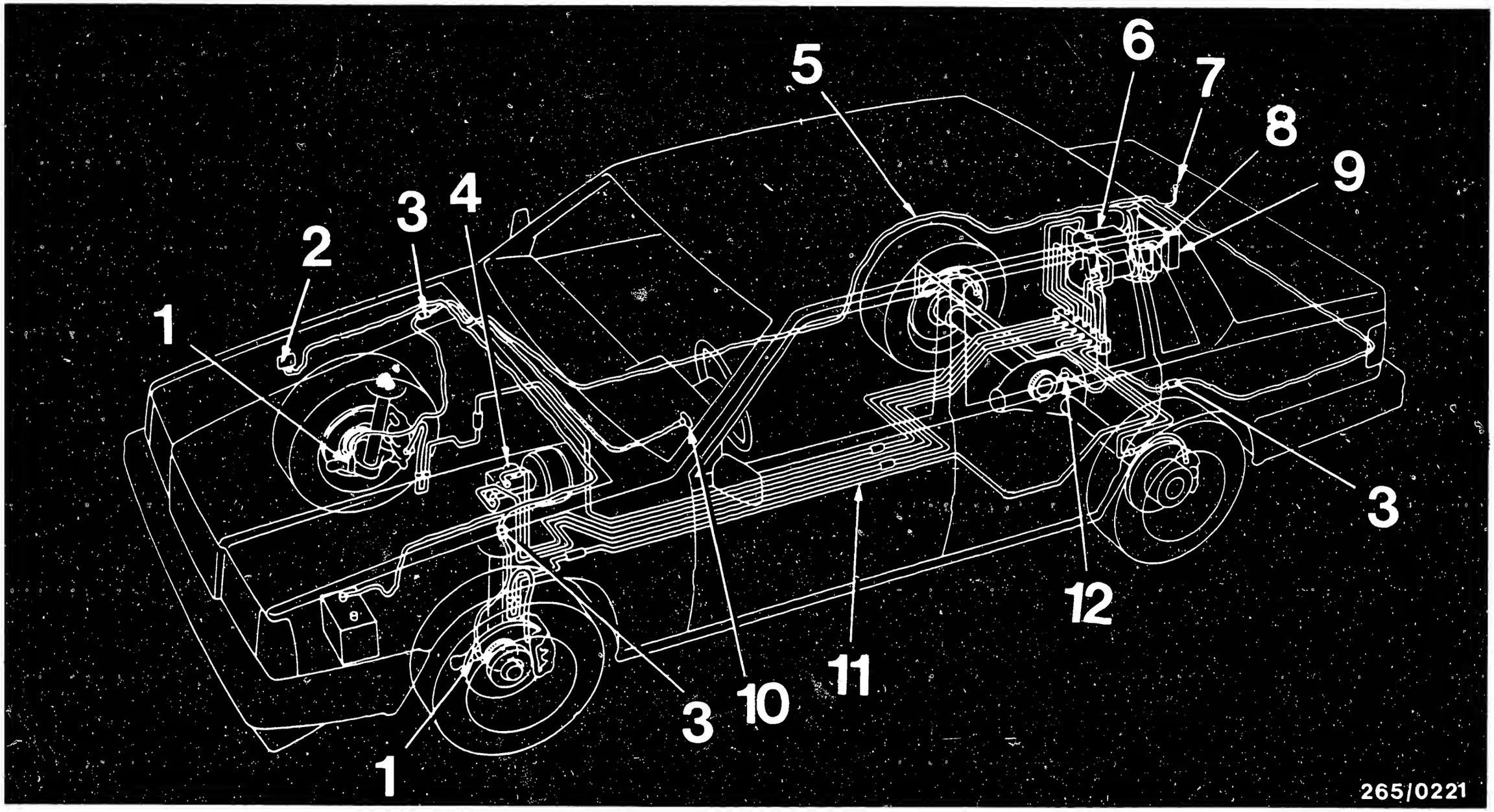
- Ground terminal for ABS:
  In luggage compartment on right-hand rear lamp.

- Controller:
  In luggage compartment on right.

- Overvoltage-protection relay:
  In luggage compartment on right.

- Control unit for electronic traction control (ETC, if applicable):
  In passenger compartment next to pedal block.

- Control unit for signal conversion:
  In luggage compartment on right.



1 = Front-axle wheel-speed sensor
2 = ABS fuse box
3 = Wheel-speed sensor plug connectors
4 = Brake assembly with brake master cylinder
5 = ABS wiring harness
6 = Hydraulic modulator
7 = Ground terminal
8 = Overvoltage-protection relay
9 = Controller
10 = Warning lamp
11 = Brake lines
12 = Rear-axle wheel-speed sensor

Installation position of components (continued)

Checking the brake system for leaks

	High-pressure test	Low-pressure test
Line test pressure Gauge pressure	50...90 bar	3 bar
Test duration	5 minutes	2 minutes
Pressure drop of set value	5 % (max.)	0 %

Note
The leakage check, which must be performed in both brake circuits, comprises high-pressure and low-pressure testing.

High-pressure test

- Connect pressure tester to fixed caliper. To do this, unscrew bleeder screw and screw in fitting. Then bleed pressure tester.

- Allow engine to run at medium speed and generate as high a vacuum as possible by suddenly releasing the accelerator pedal.

- Using the brake-pedal actuating device, press in brake pedal until a line pressure of 50...90 bar gauge pressure is produced. Then hold brake pedal in this position.

- During the test duration of 5 minutes the pressure drop must not be greater than 5 %. If there is a greater pressure drop, the leak (brake master cylinder, brake hoses, brake pipes, brake caliper) must be found and remedied, or the hydraulic modulator must be replaced.

Low pressure test

- Release brake pedal actuating device until a line pressure of 3 bar gauge pressure is indicated on the pressure gauge.

- During a test duration of 2 minutes the set pressure must not drop more than 1 bar. If there is a greater pressure drop, the leak must be found and remedied, and the brake master cylinder or the hydraulic modulator must be replaced.

Motor Vehicle Service Information

Only for internal use. Should not be passed on to any other person or persons.

Motor vehicle : Pass. car
05.1988

REPAIR BAN/
MAXIMUM PERMISSIBLE STORAGE PERIOD FOR
ABS AND ETC HYDRAULIC MODULATORS

0105 En

1. Repair ban

Passenger-car ABS systems and passenger-car ABS systems with ETC are safety features.
Impermissible tampering with ABS and ETC components could lead to impairment of the ABS and/or ABS/ETC system.

We should therefore like to point out that hydraulic modulators are never to be repaired, but only replaced as a complete unit for safety reasons.

All that is permitted with ABS hydraulic modulators is replacement of the motor and valve relay.
All other screws/bolts and plugs on hydraulic modulators a r e n o t t o b e loosened.

2. Maximum permissible storage period

The maximum permissible storage period for hydraulic modulators is 5 years calculated as of the date of manufacture (FD) indicated on the product.

The following storage conditions must be satisfied:
- Hydraulic modulator filled with brake fluid (supplied filled by Bosch).
- Perpendicular/upright position/location (cap at top).
- Ambient temperature between -20 °C and +50 °C. Dry storage.

After 5 years storage, all rubber and plastic parts are to be replaced and the hydraulic modulator is to be subjected to a functional test.

Only the supplier can carry out replacement of the rubber/plastic parts and perform the functional test. After checking, the hydraulic modulators are marked with an L in the repair identifier and given a new FD (date of manufacture).

After-sales-service workshops in West Germany should send hydraulic modulators to :

Robert Bosch GmbH, Abt. Kl/VAK 2,
Robert-Bosch-Straße, 7141 Schwieberdingen.

After-sales-service workshops in other countries should send hydraulic modulators to:

Robert Bosch GmbH KH/LAV 2 - Auspackraum
(Unpacking department).
For handover to Kl/VAK 2, Auf der Breite 2,
7500 Karlsruhe 41, West Germany

It is to be ensured that all lines are plugged.

The hydraulic modulators are to be submitted at no expense to us. Please make reference to this Technical Bulletin on the enclosed delivery note.

Parts will be replaced and the functional test performed at the submitter's expense.

Published by:

ROBERT BOSCH GMBH
Division KH
Technical After-Sales Service (KH/VKD 2)

Please direct questions and comments concerning the contents to our authorized representative in your country.

Edmund Klaiss OHG
Bosch-Vertragsgroßhändler
Neuenkamper Str. 22 - 28
5630 Remscheid

Ludwig Klaps KG
Bosch-Vertragsgroßhändler
Hemelter Str. 74 - 78
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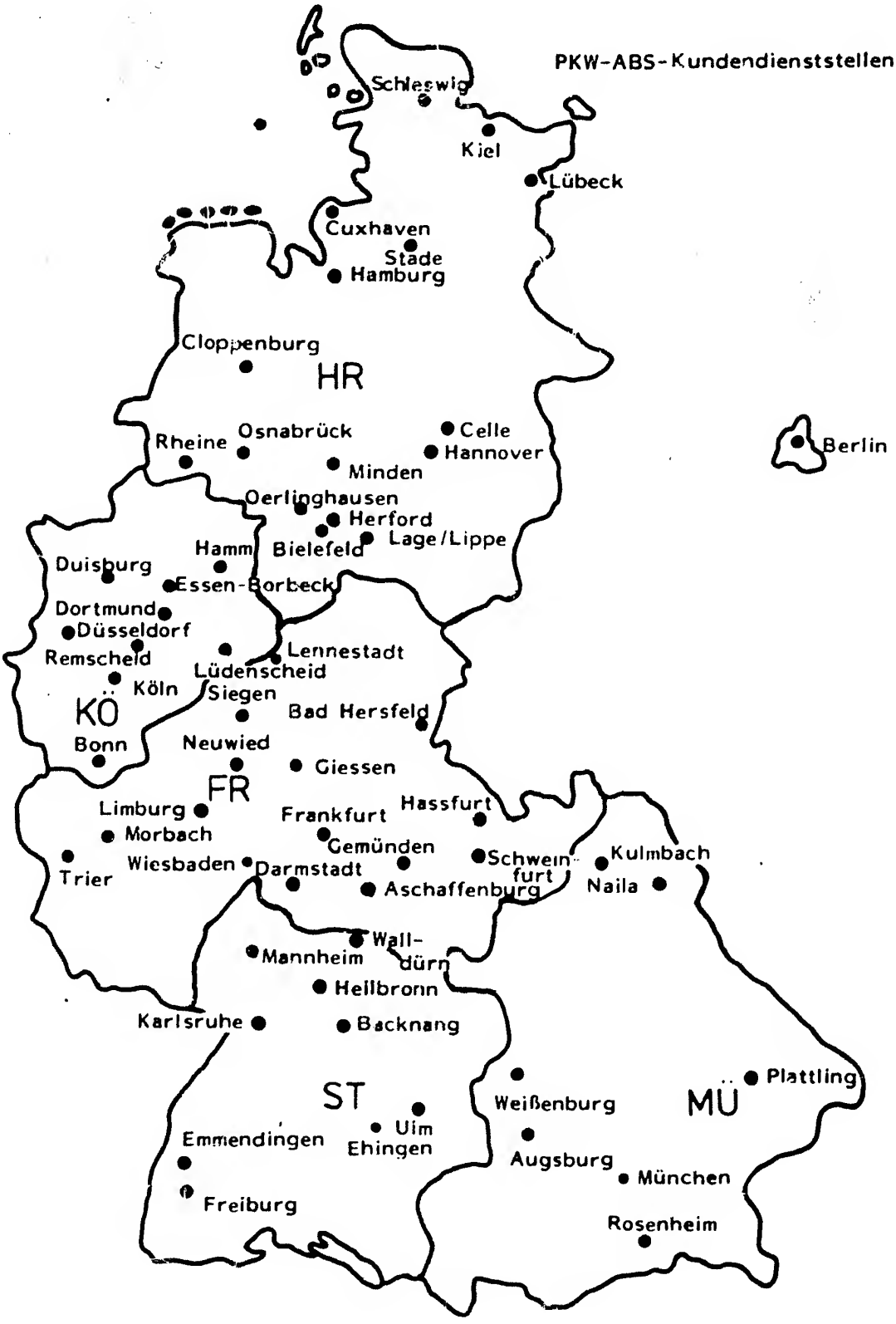
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INHALTSVERZEICHNIS

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